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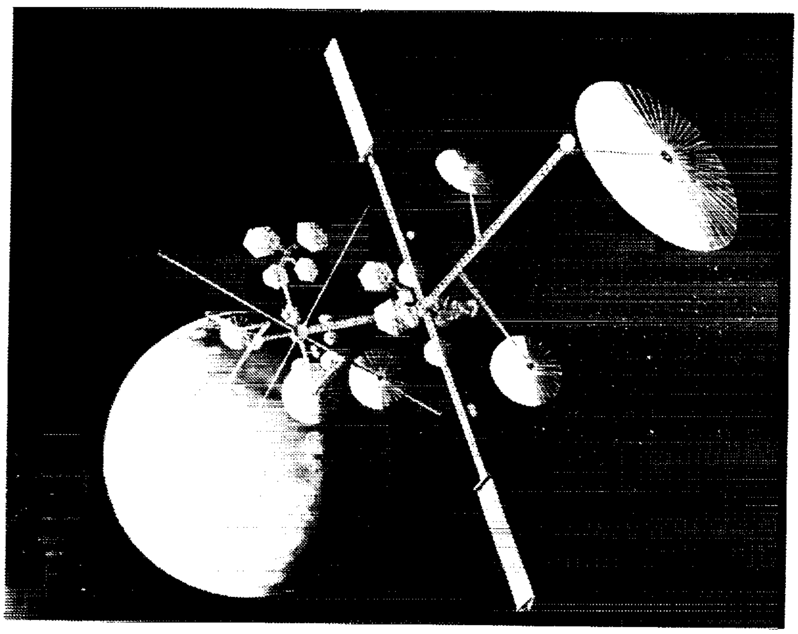
SEPTEMBER 1981

GEOSTATIONARY PLATFORM SYSTEMS CONCEPTS DEFINITION FOLLOW-ON STUDY

FINAL REPORT
VOLUME III
COSTS AND SCHEDULES (TASK 10)



Prepared by

GENERAL DYNAMICS
Convair Division

&

COMSAT

for the

National Aeronautics and Space Administration
GEORGE C. MARSHALL SPACE FLIGHT CENTER
Huntsville, Alabama

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VOLUME III
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(TASK 10)

September 1981

Submitted to
GEORGE C. MARSHALL SPACE FLIGHT CENTER
National Aeronautics and Space Administration
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GEOSTATIONARY PLATFORM
SYSTEMS CONCEPTS DEFINITION
FOLLOW-ON STUDY

FINAL REPORT

VOLUME I	Executive Summary
VOLUME IIA (Published September 1980)	Technical Analysis, Task 11
VOLUME IIB	Technical Analysis, Tasks 8&9
VOLUME III	Costs & Schedules, Task 10

This volume of the final report is submitted in partial fulfillment of NASA/ MSFC Contract NAS8-33527 (extended).

Publication of this report does not constitute approval by the National Aeronautics and Space Administration of the reports findings or conclusions.

1 September 1981

William T. Carey

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PREFACE

In today's world of expanding communication services, the geostationary orbit is rapidly becoming an extremely valuable and limited earth resource. Nations demand specific positions or "slots" in the orbit corresponding to their geographic longitude, seeking to maximize their territorial coverage and satellite performance. Common carriers within a developed nation demand equal rights for the best slots. Competition has been strong in the developed nations, and the developing nations are now voicing their concern.

At geosynchronous altitude, independent satellites operating at the same frequency must be separated by about 4 degrees of longitude to prevent RF interference (30 dB separation), dictated by the large beamwidths of the small affordable ground antennas now in use. About 90 "slots", therefore, exist around the world, with about 12 over the U.S. and our northern and southern neighbors.

The frequency spectrum is also a valuable and limited resource that is rapidly approaching saturation, particularly in those regions of low noise and freedom from atmospheric attenuation.

Both resources are now allocated worldwide by the International Telecommunications Union operating through subservient multinational and national agencies. Reallocation cannot solve our basic orbital arc and frequency-saturation problems. Recent studies have shown projected traffic demands that will saturate both the geostationary orbital arc and the optimal-frequency spectra in the near future.

Motivation for the rapid adoption of satellite communications services in the past decade has been primarily economic. Still further economies can be realized if the cost, complexity, and size of ground stations can be reduced by the use of satellites with expanded capabilities, using advanced communications and support technologies.

What is the solution to our orbital arc and frequency spectrum saturation problems, a solution that would also result in reduced user costs?

One viable solution is the aggregation of many transponders, large antennas, and connectivity switches on board large geostationary satellites, or platforms. One such platform can provide common power and housekeeping services to a number of coexistent communications systems, making maximum use of each orbital slot, and taking advantage of the economies of scale inherent in such large systems. The economies are manifested in overall reduced mass in orbit, lower bus mass per pound of payload, somewhat lower production costs per pound of hardware, and much lower transportation cost per pound through more efficient utilization of the STS capabilities.

Through multibeam frequency reuse of large antennas at several frequencies, interconnected with on-board switching and processing, a single spacecraft of the platform type could provide over half a million voice circuits. A system of such platforms can provide an equivalent transponder capacity over the U.S. at least an order of magnitude greater than the projected traffic demand for the year 2000. Such a system would significantly reduce the cost of services. The higher beam power would enable earth stations to be small, simple, and inexpensive and would make a host of new types of service affordable.

Platforms can also provide facility support and opportunity for missions other than communications services. Science experiments, science observation and data-gathering, and technology development are prime candidates. Such missions include earth observation (weather, lightning mapping, resources), solar system observation, space environment, astronomy, materials for space, and many others. All can be accommodated on platforms at reduced investment and operations costs.

In 1978, NASA initiated feasibility studies to encourage development of geostationary platforms at lower costs, anticipating the need for increased communications services in the near decades. These studies established the need and requirements for, and the feasibility of, such platforms. NASA's George C. Marshall Space Flight Center has the responsibility for implementing the Geostationary Platform Program.

The Geostationary Platform Phase A Initial Study, under the direction of the Marshall Space Flight Center, was performed by the General Dynamics Convair Division of San Diego with Comsat Corporation of Clarksburg, Maryland, as subcontractor. The study was completed in June 1980 and dealt primarily with the requirements, missions, concepts, and programmatics of operational geostationary platforms of the 1990s. Objective of the study was to establish a basis for development of an experimental geostationary platform with a mid-1980s launch, paving the way for the operational platforms of the 1990s.

A follow-on study was authorized 1 April 1980 to reevaluate and update operational platform requirements, identify experimental platform concepts, and accommodate a special task for the Large Space Systems Technology (LSST) program management.

This report documents the results of the Geostationary Platform Follow-On Study, performed by the General Dynamics Convair Division of San Diego with COMSAT General Corporation of Washington, D.C., as subcontractor, under direction of the Marshall Space Flight Center. Period of performance was from 1 April 1980 to 1 July 1981.

Results of the LSST special task were published in September 1980 as an early volume (IIA) of the Follow-On Study final report.

All other results of the Follow-On Study will be found in Volumes I, IIB, and III of the final report, as identified on page ii of this volume.

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SECTION 1

SUMMARY

The George C. Marshall Space Flight Center (MSFC) has the responsibility within the NASA for the geostationary platform - to initiate conceptual studies, develop feasible concepts, coordinate user needs and technology requirements, and promote activities aimed at system hardware solutions to the projected service demands of the 1990s. The schedule, Figure 1-1, provides for a National Aeronautics and Space Administration (NASA) experimental platform in 1989 to validate required technology and to support operational platforms with launch dates in the 1990s.

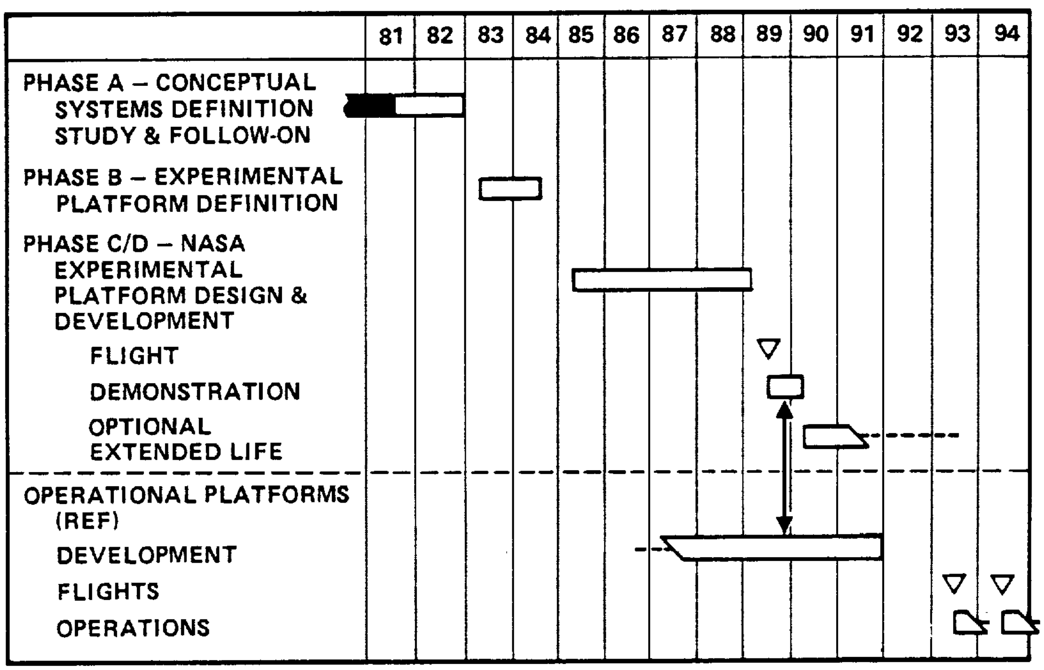

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Figure 1-1. Projected Development Schedule for Geostationary Platforms

On 1 June 1979, General Dynamics Convair was placed under contract to do the Initial Phase A Concepts Definition Study for the Geostationary Platform. Thrust of the study was toward conceptual definition of operational geostationary platforms of the 1990s to provide a data base for definition of an experimental geostationary platform. Results of the initial study confirmed the need for a follow-on study to further define technology requirements, configuration, and communications architecture of operational platforms, and to develop a preliminary definition of an experimental platform.

In April 1980, the Initial Study contract was extended to include the Follow-on Study. Objectives of the Follow-On study were to update the initial study; analyze, identify operations, evaluate, and select a preferred experimental platform concept; and identify requirements in the area of Large Space Systems Technology (LSST).

To attain these objectives, four tasks were defined in the NASA Statement of Work for this study, continuing the sequence of tasks beyond the original seven tasks in the initial study:

Task 8 - Operational Platforms (Initial Study) Update.
Refine and update results of the Initial Study pertaining to operational geostationary platforms of the 1990s to reflect updated traffic models, trades, new payload requirements, and configurations.

Task 9 - Experimental Platform Analysis and Definition.
Analyze, identify, and evaluate options for a mid-1980s experimental platform; select a preferred concept; and develop a preliminary definition of the preferred concept.

Task 10 - Programmatic (Cost and Schedule) Data Development.
Define and develop Phase C/D cost and schedule data for the candidate operational systems and the selected experimental platform concept.

Task 11 - LSST Special Emphasis Task.
Further define candidate operational geostationary platform concepts for the 1990s and identify requirements in the area of LSST.

This document, Volume III of the Final Report, summarizes the results of Task 10, the programmatic and cost analyses accomplished during this study in accordance with the requirements of the Statement of Work, the Study Plan, and DPD MF 02A, dated 2 February 1979.

The principal objectives of Task 10 were to:

a. Update the cost estimates for the RIA and the AA-2 operational concepts using the final system definitions and updated cost estimating methodology.

b. Develop a preliminary cost estimate and program schedule for the candidate experimental platform as defined in Task 9D.

Section 2 of this volume contains the refined cost estimates of the current configurations of three alternate approaches to the operational system and a brief technical description of each concept.

Section 3 includes a preliminary cost estimate and funding requirements for the initial definition of the experimental platform development program, a brief description of the project, a summary development schedule, and a WBS dictionary for the project.

SECTION 2
OPERATIONAL SYSTEM UPDATE

The cost analysis task documented herein (Task 10A) is concerned with update of the cost estimates for the operational geostationary platform system (Reference 1) to reflect system concept evolution including refined platform configurations and revised payload complements. Cost estimates were generated or updated for three system configurations, specifically: (a) the Revised Initial Architecture (RIA) Alternative 1 (constellation configuration), (b) Alternative Architecture No. 2 (AA-2) Alternative 2 (docked configuration), and (c) RIA Alternative 2 (docked configuration), as identified in Figure 2-1. This section presents a brief description of these operational concepts, their platforms and payloads, the input data used to develop the cost estimates, and the cost estimates themselves.

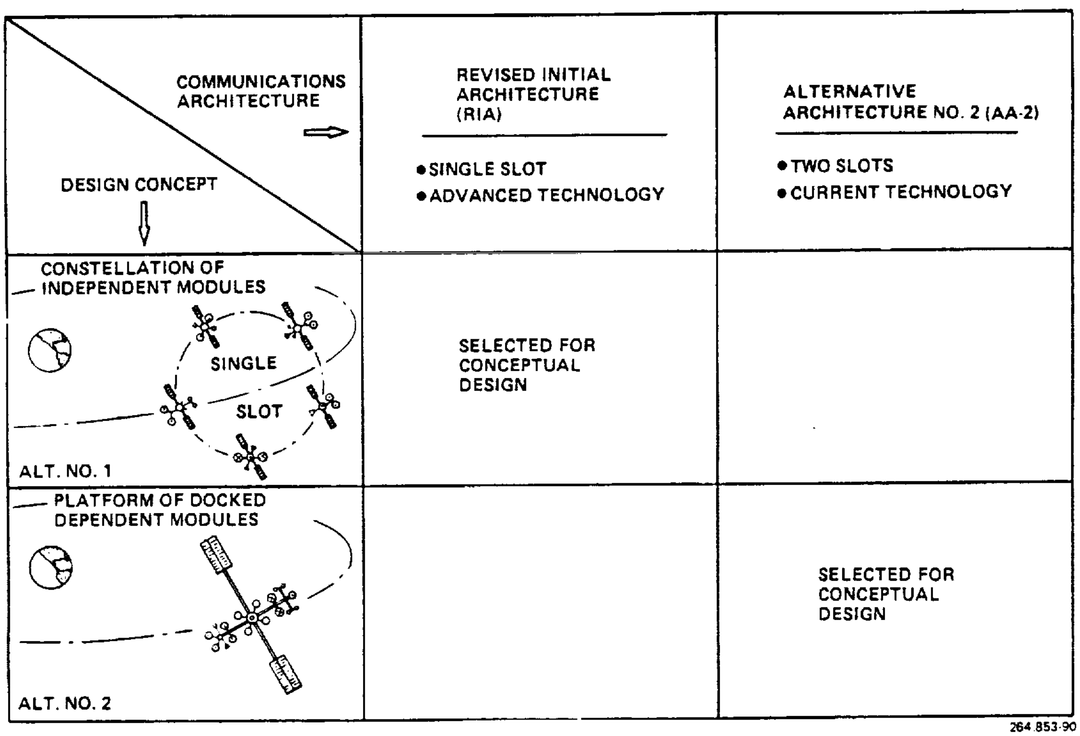

Figure 2-1. Operational Geostationary Platform Alternatives

2.1 SYSTEM DESCRIPTION

The operational systems selected in the initial study (Reference 3) have been revised and have evolved in this follow-on study effort. The concepts considered herein are designed to accommodate the nominal traffic model associated with Western Hemisphere coverage at 110 (±2) degrees west longitude, as defined in the initial study. In addition to the principal High Volume Trunking (HVT) and Direct-to-User (DTU) communications payloads, the platforms accommodate 8 other communications payloads and 16 scientific payloads.

The concepts consist of two basic approaches to platform orbital configuration. Alternative No. 1 consists of a constellation of free-flying modules each being launched by a separate Shuttle flight, including an OTV that transports the platform module from LEO to GEO. By judicious selection of orbital parameters, such a group of satellites in a spherically symmetric gravity field can be made to form a ring-like constellation in which, to an observer on Earth, all satellites (modules) appear to be fixed on the circumference of a circle that rotates once per day about a perpendicular axis through its center. This was shown diagrammatically in Figure 2-1. The proposed constellation would be about 10km in diameter and would be located in geostationary orbit. These free-flying individual platform modules are linked by an RF communication system using interplatform links (IPL) in each orbital slot.

Design concept Alternative No. 2 consists of a platform in each of one or more orbital slots, each platform made up of two or more modules docked together after having been individually placed in orbit with the Shuttle and OTV. Figure 2-1 also illustrates diagrammatically such a platform in a single slot. Geostationary slots are about 4 degrees of longitude apart (approximately 1600 n.mi.).

In addition to these physical configurations, two different basic communication system architectures were considered:

a. Revised Initial Architecture (RIA), which makes use of a single slot at geostationary orbit and a beam separation $\geq$ 2 beamwidths.

b. Alternative Architecture No. 2 (AA-2), which makes use of two slots at geostationary orbit separated by about 4 degrees of longitude, with beam separation $\geq \sqrt{7}$ beamwidths for DTU and $\geq$ 3 beamwidths for HVT.

Of the four possible combinations of architecture and configuration, costs were estimated for three cases, namely, RIA Alternatives 1 and 2, and AA-2 Architecture 2. The subsequent discussion summarizes the payloads and the platform technical characteristics.

2.1.1 PAYLOAD DESCRIPTION. The communication and scientific payloads accommodated on these concepts are summarized in Tables 2-1 and 2-2, respectively. Module-by-module payload assignments for the three cases are identified in Tables 2-3, 2-4, and 2-5, respectively.

Table 2-1. Communications Payload Characteristics Summary

Type	PL No.	Description	Frequency		Beams			Antennas					Power		Mass				Remarks
			Up	Down	No.	BW°	Ptg. Accy.	Focal Length	Dish Dia.	Feed Size	Feed Area	No. Xpdrs.	RF	DC Input	Dish & Gimbal	Feed	Other Avionics	Total (W15%)	
RIA Alternative No. 1	1.1 KuVE	DTU	14	11	66	0.35	0.036	8.3	7.1	0.84D	0.261	158	308	770	62	76	232	413	
	1.1 KuHE	DTU			9						0.084	25	49	122		12	56	138	
	1.1 KuHW	DTU			95						0.289	165	322	804		106	238	458	
	1.1 KuVW	DTU			3						0.011	12	24	59		5	28	99	
	1.1 KuVM	DTU			43						0.094	17	33	83		49	39	162	
	1.3 KuHP	DTU/HVT			33						0.163	74	162	405		39	151	278	
	1.3 KuVB	DTU/HVT			47						0.333	70	148	369		55	141	285	Includes: 29% redundancy factor on all masses.
	1.3 KuHA	DTU/HVT	14	11	32	0.35	0.036	8.3	7.1	0.84D	0.112	70	155	388	52	37	146	271	
	1.3 KaHE	DTU/HVT	30	20	20	0.35	0.035	4.3	3.9	0.47D	0.028	191	1303	3267	47	11	458	591	15% contingency factor in last column only.
	1.2 KaVE	HVT			7						0.027	73	551	1378		5	337	448	
	1.2 KaVW	HVT	30	20	12	0.35	0.035	4.3	3.9	0.47D	0.083	120	906	2265	47	8	408	634	
	1.3 CTG	DTU/HVT	–	4	28	1.0	0.10	9.4	6.8	3.0D	2.53	205	329	1314	44	152	281	697	
	1.3 CRG		6	–	28	1.0	0.10	9.4	4.6	2.7D	2.05				37	92			
AA-2 Alternative No. 2	1.1 KuVE	DTU	14	11	68	0.35	0.035	8.3	7.1	0.84D	0.312	117	228	670	62	77	192	370	
	1.1 KuHE	DTU			39						0.287	71	138	346		48	134	267	
	1.1 KuH	DTU			80						0.305	126	246	614		90	202	396	
	1.1 KuVW	DTU			17						0.267	30	59	146		22	66	161	
	1.1 KuVM	DTU			43						0.194	17	33	83		50	39	162	
	1.1 KuHP	DTU			28						0.163	63	103	258		33	106	221	
	1.1 KuVB	DTU			43						0.333	67	111	278		61	113	248	
	1.1 KuHA	DTU	14	11	29	0.35	0.035	8.3	7.1	0.84D	0.112	48	94	234	52	34	92	212	
	1.3 KaUE	DTU/HVT	30	20	19	0.35	0.036	4.3	3.9	0.47D	0.198	177	1284	3210	47	12	454	690	
	1.3 KaUW	DTU/HVT	30	20	92	0.35	0.035	4.3	3.9	0.47D	0.349	100	748	1866	47	47	382	547	
	1.3 CTG	DTU/HVT	–	4	29	1.0	0.10	9.4	6.8	3.0D	2.53	175	280	1121	44	157	260	682	
	1.3 CRG	DTU/HVT	6	–	29	1.0	0.10	9.4	4.6	2.7D	2.05				37	95			
	2.1 KuVE	DTU	14	11	11	0.35	0.035	8.3	7.1	0.84D	0.086	24	47	117	52	14	64	139	
	2.1 KuHE	DTU	14	11	11	0.35	0.035	8.3	7.1	0.84D	0.086	26	61	127	52	14	58	143	
	2.2 KaUE	HVT	30	20	3	1.06	0.10	1.6	0.9		0.022	55	415	1038	34	4	294	382	
	2.2 CTG	HVT	–	4	14	1.0	0.10	9.4	6.8	3.0D	2.53	104	168	671	44	85	196	477	
	2.2 CRG	HVT	6	–	14	1.0	0.10	9.4	4.6	2.7D	2.05				57	54			
Communications Payloads Other Than DTU/HVT	3 (Ku)	TV Distribution	17.0	12.0	61	1.0	0.1	3.0	1.5	0.3 dia.	3.16	76	760	4000				515	North America, C.A., S.A.
			17.0	12.0		1.0	0.1	3.0	1.5	0.3 dia.	1.56								
	4 (Ku)	Tracking & Data Relay	2.2/15	2.1/14	1	2.0/0.3	0.04	2.0	5.0	–	–	1	26/1.5	680				425	Hemispheric
			2.2/16	2.1/14	1	2.0/0.3	0.04	2.0	6.0	–		1	26/1.5						Hemispheric
			15.0	14.0	1	0.7/0.8	0.1	1.0	2.5	–		1	30						Ground Station
			2.2	2.1	20	8.0	0.1	30 x 30 Array				1	TBD						Hemispheric
	5 (S/Ku)	Educational TV	(Uses DTU channel for uplink)	2.5	1	3.5	0.3	2.5	2.5	0.5 dia.		16	96	400				620	CONUS – Pacific Time Zone CONUS – Mountain Time Zone CONUS – Central Time Zone CONUS – Eastern Time Zone Mexico, C.A. S.A. – North S.A – Central S.A – South
									2.5										
									1.5										
				2.5	1	3.5	0.3	2.5	1.5	0.5 dia.									
	6 (Ku)	Direct-to-home TV	14.0		1	1.0	0.1	0.9	1.5	0.6		8	800	2100				515	Ground Station
	(UHF)			0.7	6	3 x 4	0.3	6.0	10.0	1.8									Hemispheric
	7 (L)	Air Mobile	1.6	1.5	1	Shaped	0.5	–	–	Array		2	200	1200				260	Hemispheric
	(C)		6.0	5.0	1	18.0	0.5	–	–	Horn		2	20						Hemispheric
	9 (UHF)	Land Mobile	0.9	0.8	21	1.5	0.1	15.0	20.0	2.7 x 1.3		100	1000	4000				685	CONUS, Alaska, Hawaii, Virgin Islands
	11 (K/Q)	Inter-platform link	32.0	25.0	2	0.3	0.03	1.0	2.4	–		2	130	300				130	To other platforms
	12 (UHF)	Data Collection	0.4	0.4	4	5.0	0.1	5.0	10.0	1.0	–	4	4	100				130	Hemispheric

Table 2-2. Scientific Payload Characteristics Summary

Type	Payload ID	Payload Description	Input DC Power (Watts)	Total Mass (kg)
Scientific	17	Lightning Mapper	300	320
	18	Atmospheric Sounder	50	185
	19	Visual & IR Radiometer	100	500
	20	Microwave Radiometer	150	136
	27	RF Interferometer	220	120
	31	DMSP Data Relay	100	195
	32	OLS Cloud Imager	150	150
	33	Materials Exposure	25	10
	38	Aerosol & Cloud Sensor	100	50
	42	Global UV Radiance	20	50
	43	Magnetic Substorm Monitor	5	10
	52	BOSS Evaluation	400	150
	54	DoD EHF Experiment	500	230
	55	DoD Laser Communication	550	320
	56	Fiber Optics Demonstration	30	10
	71	Earth Optical Telescope	2000	1100

* Includes 29% for redundancy, plus 15% contingency. Other masses as provided by supplier.

2.1.2 PLATFORM DESCRIPTION. The general requirements for the operational platforms are given below. The system shall:

a. Consist of modules.

   1. Each module to be transportable from LEO to GEO by NASA Low-Thrust Expendable OTV (offloaded).

   2. Each module to be packagable in Shuttle cargo bay together with OTV.

   3. Module weight, plus OTV and ASE, is not to exceed Shuttle lift capability to LEO (i.e., 29,484 kg (65,000 lb)).

b. Have a 16 year lifetime with 8 years of consumables replaceable via logistics flights.

c. Have high reliability. (A weight allowance of 29% has been made to permit triple redundancy of avionic elements.)

d. Provide electrical power and thermal control for the payloads, as required.

e. Provide attitude control and stationkeeping within specified requirements.

Table 2-3. RIA Alternative 1 Payload Assignments

PAYLOAD NUMBER	PAYLOAD FUNCTION	MODULE NUMBER 1	2	3	4	5	6	7	8
1.1 KuVE	DTU, Ku BAND		X						
1.1 KuHE	DTU, Ku BAND		X						
1.1 KuHW	DTU, Ku BAND		X						
1.1 KuVW	DTU, Ku BAND		X						
1.1 KuVM	DTU, Ku BAND			X					
1.3 KuHP	DTU/HVT, Ku BAND			X					
1.3 KuVB	DTU/HVT, Ku BAND			X					
1.3 KuHA	DTU/HVT, Ku BAND			X					
1.3 KaHE	DTU/HVT, Ka BAND		X						
1.2 KaVE	HVT, Ka BAND		X						
1.2 KaVW	HVT, Ka BAND			X					
1.3 CTG	DTU/HVT, C BAND				X				
1.3 CRG	DTU/HVT, C BAND				X				
3	TV DISTRIBUTION	X							
4	TRACKING & DATA RELAY							X	
5	EDUCATIONAL TV						X		
6	DIRECT-TO-HOME TV					X			
7	AIR MOBILE			X					
9	LAND MOBILE					X			
11	INTER-PLATFORM LINK	X	X	X	X	X	X	X	X
12	DATA COLLECTION				X				
17	LIGHTNING MAPPER							X	
18	ATMOSPHERIC SOUNDER								X
19	VISUAL & IR RADIOMETER				X				
20	MICROWAVE RADIOMETER								X
27	RF INTERFEROMETER	X							
31	DMSP DATA RELAY				X				
32	OLS CLOUD IMAGER							X	
33	MATERIALS EXPOSURE					X			
38	CLOUD HEIGHT SENSOR							X	
42	GLOBAL UV RADIANCE							X	
43	MAGNETIC SUBSTORM MONITOR					X			
52	BOSS EVALUATION	X							
54	DOD EHF EXPERIMENT							X	
55	DOD LASER COMMUNICATION							X	
56	FIBER OPTICS DEMO					X			
71	EARTH OPTICAL TELESCOPE								X

*MODULE NUMBERS DO NOT REPRESENT LAUNCH SEQUENCE.

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Table 2-4. RIA Alternative 2 Payload Assignments

PAYLOAD NUMBER	PAYLOAD FUNCTION	MODULE NUMBER *					
		1	2	3	4	5	6
1.1 KuVE	DTU, Ku BAND		X				
1.1 KuHE	DTU, Ku BAND		X				
1.1 KuHW	DTU, Ku BAND		X				
1.1 KuVW	DTU, Ku BAND		X				
1.1 KuVM	DTU, Ku BAND			X			
1.3 KuHP	DTU/HVT, Ku BAND			X			
1.3 KuVB	DTU/HVT, Ku BAND			X			
1.3 KuHA	DTU/HVT, Ku BAND			X			
1.3 KaHE	DTU/HVT, Ka BAND		X				
1.2 KaVE	HVT, Ka BAND				X		
1.3 KaVW	HVT, Ka BAND		X				
1.3 CTG	DTU/HVT, C BAND				X		
1.3 CRG	DTU/HVT, C BAND				X		
3	TV DISTRIBUTION	X					
4	TRACKING & DATA RELAY						X
5	EDUCATIONAL TV			X			
6	DIRECT-TO-HOME TV						X
7	AIR MOBILE						X
9	LAND MOBILE						X
11	INTER-PLATFORM LINK	X					
12	DATA COLLECTION				X		
17	LIGHTNING MAPPER				X		
18	ATMOSPHERIC SOUNDER				X		
19	VISUAL & IR RADIOMETER				X		
20	MICROWAVE RADIOMETER				X		
27	RF INTERFEROMETER					X	
31	DMSP DATA RELAY				X		
32	OLS CLOUD IMAGER		X				
33	MATERIALS EXPOSURE				X		
38	CLOUD HEIGHT SENSOR		X				
42	GLOBAL UV RADIANCE					X	
43	MAGNETIC SUBSTORM MONITOR				X		
52	BOSS EVALUATION		X				
54	DOD EHF EXPERIMENT			X			
55	DOD LASER COMMUNICATION					X	
56	FIBER OPTICS DEMO			X			
71	EARTH OPTICAL TELESCOPE						X

*MODULE NUMBERS DO NOT REPRESENT LAUNCH SEQUENCE.

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Table 2-5. AA-2 Alternative 2 Payload Assignments

PAYLOAD NUMBER	PAYLOAD FUNCTION	MODULE NUMBER*						
		1	2	3	4	5	6	7
1.1 KuVE	DTU, Ku BAND		X					
1.1 KuHE	DTU, Ku BAND		X					
1.1 KuHW	DTU, Ku BAND		X					
1.1 KuVW	DTU, Ku BAND		X					
1.1 KuVM	DTU, Ku BAND			X				
1.1 KuHP	DTU, Ku BAND			X				
1.1 KuVB	DTU, Ku BAND			X				
1.1 KuHA	DTU, Ku BAND			X				
1.3 KaUE	DTU/HVT, Ka BAND		X					
1.3 CTG	DTU/HVT, C BAND				X			
1.3 CRG	DTU/HVT, C BAND				X			
1.3 KaUW	DTU/HVT, Ka BAND		X					
2.1 KuVE	DTU, Ku BAND							X
2.1 KuHE	DTU, Ku BAND							X
2.2 KaUE	HVT, Ka BAND					X		
2.2 CTG	HVT, C BAND						X	
2.2 CRG	HVT, C BAND						X	
3	T.V. DISTRIBUTION	X						
4	TRACKING & DATA RELAY							X
5	EDUCATIONAL TV			X				
6	DIRECT-TO-HOME TV						X	
7	AIR MOBILE						X	
9	LAND MOBILE						X	
11	INTER-PLATFORM LINK	X				X		
12	DATA COLLECTION				X			
17	LIGHTNING MAPPER							X
18	ATMOSPHERIC SOUNDER							X
19	VISUAL & IR RADIOMETER				X			
20	MICROWAVE RADIOMETER							X
27	RF INTERFEROMETER					X		
31	DMSP DATA RELAY				X			
32	OLS CLOUD IMAGER							X
33	MATERIALS EXPOSURE							X
38	CLOUD HEIGHT SENSOR							X
42	GLOBAL UV RADIANCE							X
43	MAGNETIC SUBSTORM MONITOR							X
52	BOSS EVALUATION							X
54	DOD EHF EXPERIMENT							X
55	DOD LASER COMMUNICATION							X
56	FIBER OPTICS DEMO.							X
71	EARTH OPTICAL TELESCOPE							X

*MODULE NUMBERS DO NOT REPRESENT LAUNCH SEQUENCE.

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Each platform module is launched in a single Shuttle Orbiter flight sharing the cargo bay with a low-thrust, expendable orbital transfer vehicle (OTV). After deployment and checkout in LEO, the OTV transports the module to geosynchronous earth orbit (GEO). The modules then fly formation in a constellation at their assigned longitude (Alternative 1) or dock together as single large platforms in one or more slots (Alternative 2).

The platforms are designed to have an overall lifetime of 16 years and carry consumables (reaction control propellant) and batteries for eight years. The platforms will be serviced by a Teleoperator Maneuvering System (TMS) to replace consumables and batteries periodically.

The Shuttle packaged configuration, deployment sequence, and deployed configuration are shown in Figures 2-2 through 2-5, for a typical operational system module. Figure 2-6 illustrates the rendezvous of two modules to be part of a larger single platform in the case of Alternative 2.

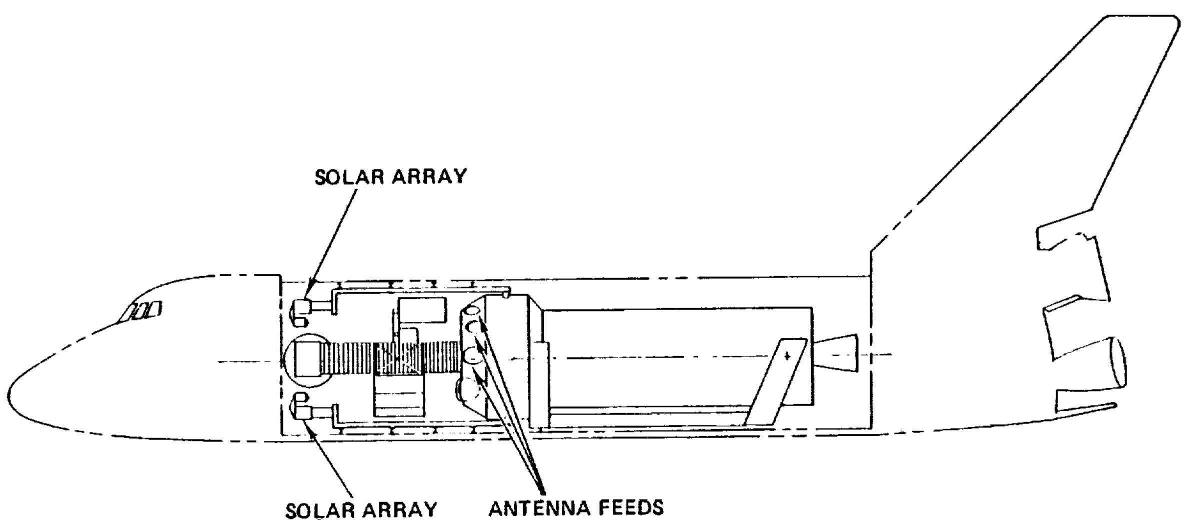

Figure 2-2. Typical Platform Module Packaged in Shuttle Orbiter

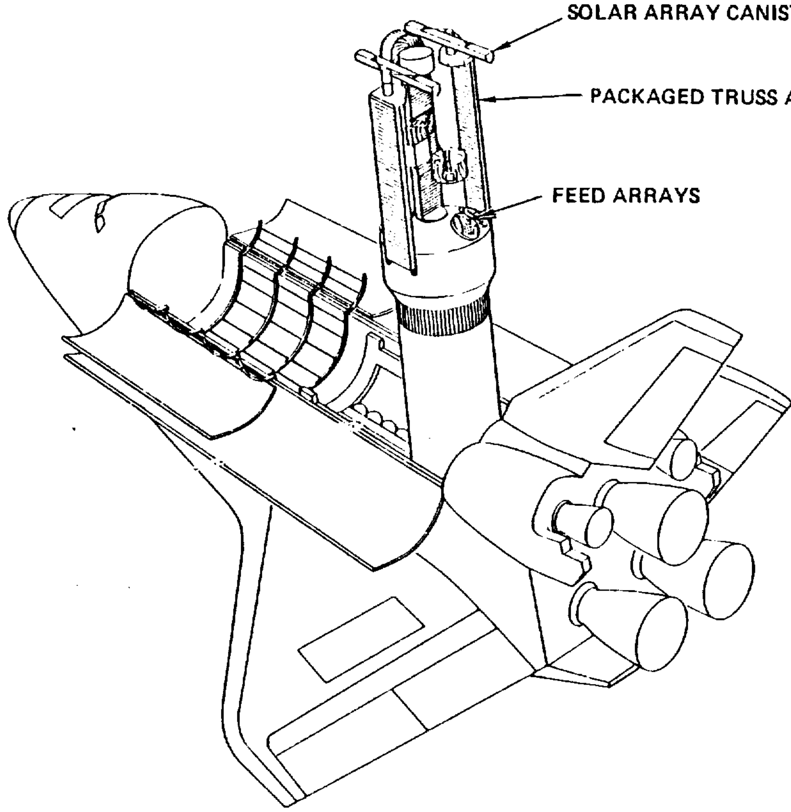

Figure 2-3. Platform Module Rotated and Ready for Deployment

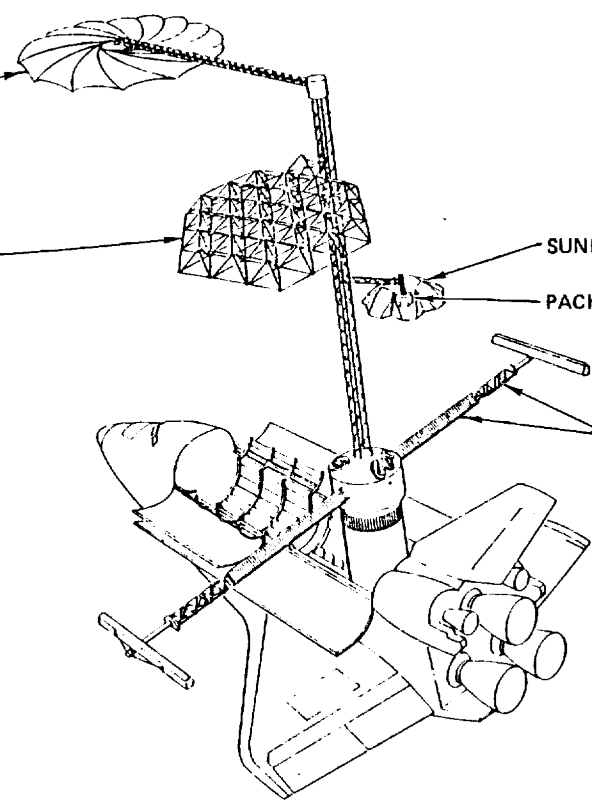

Figure 2-4. Platform Module Being Deployed

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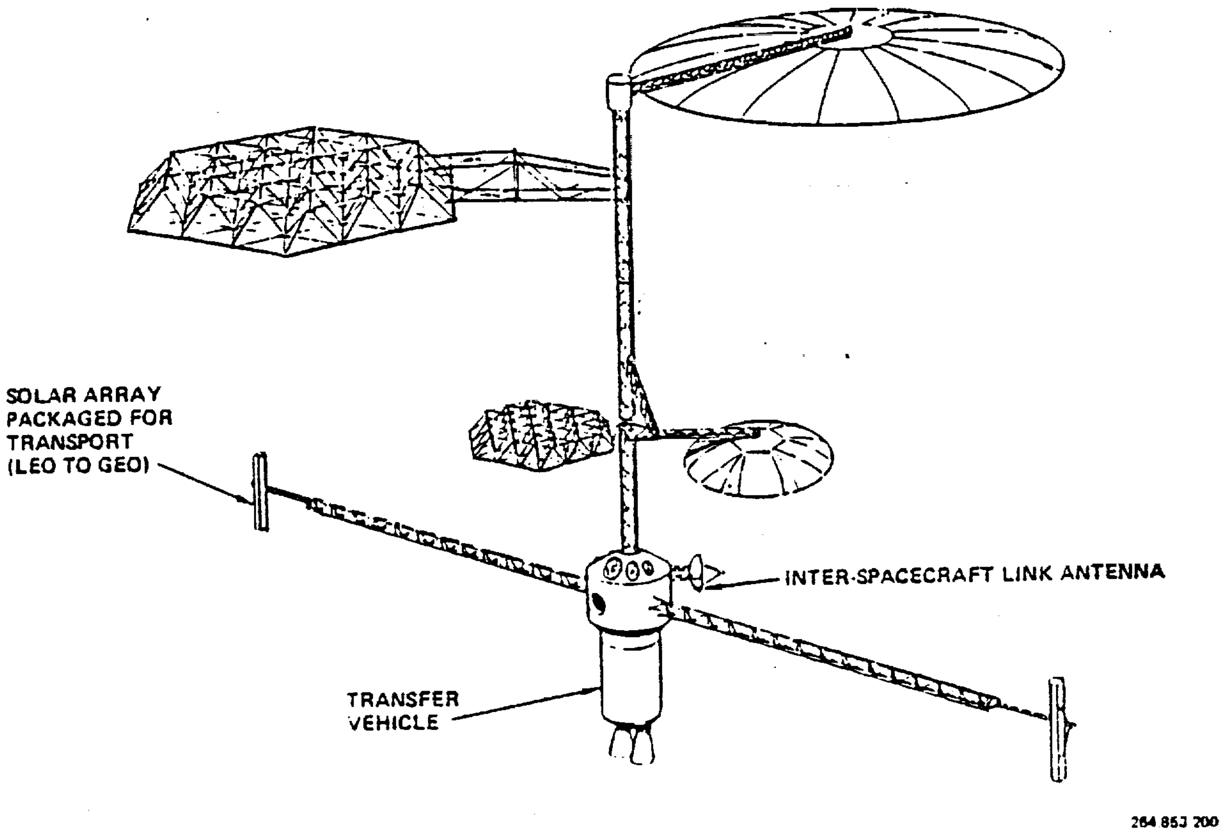

Figure 2-5. Platform Module Deployed and Ready for Transfer to GEO

The overall physical arrangement design philosophy dictates the use of offset parabolic antennas wherever possible. This permits location of feeds near a central core containing all housekeeping functions, viz., power, control systems, switches, thermal radiator, etc. Thus, power and communication transmission lines between source and feed are kept to a minimum. This is desirable since the feeds are active: they use substantial power, generate substantial heat, and tend to be dense and difficult to fold for packaging. In many cases, it has been possible to mount the unfolded feed assemblies as rigid bodies directly on the central core. Antenna reflectors, on the other hand, tend to be passive, generate little or no heat, are light, and several concepts exist for deployable designs that can be folded for efficient packaging. The antenna reflectors are mounted, wherever possible, on the ends of deployable masts and beams that will not be required to carry and deploy complicated harnesses, fiber optics, waveguides, or thermal heat pipes. Each module is also designed for the maximum possible commonality with other modules in the system.

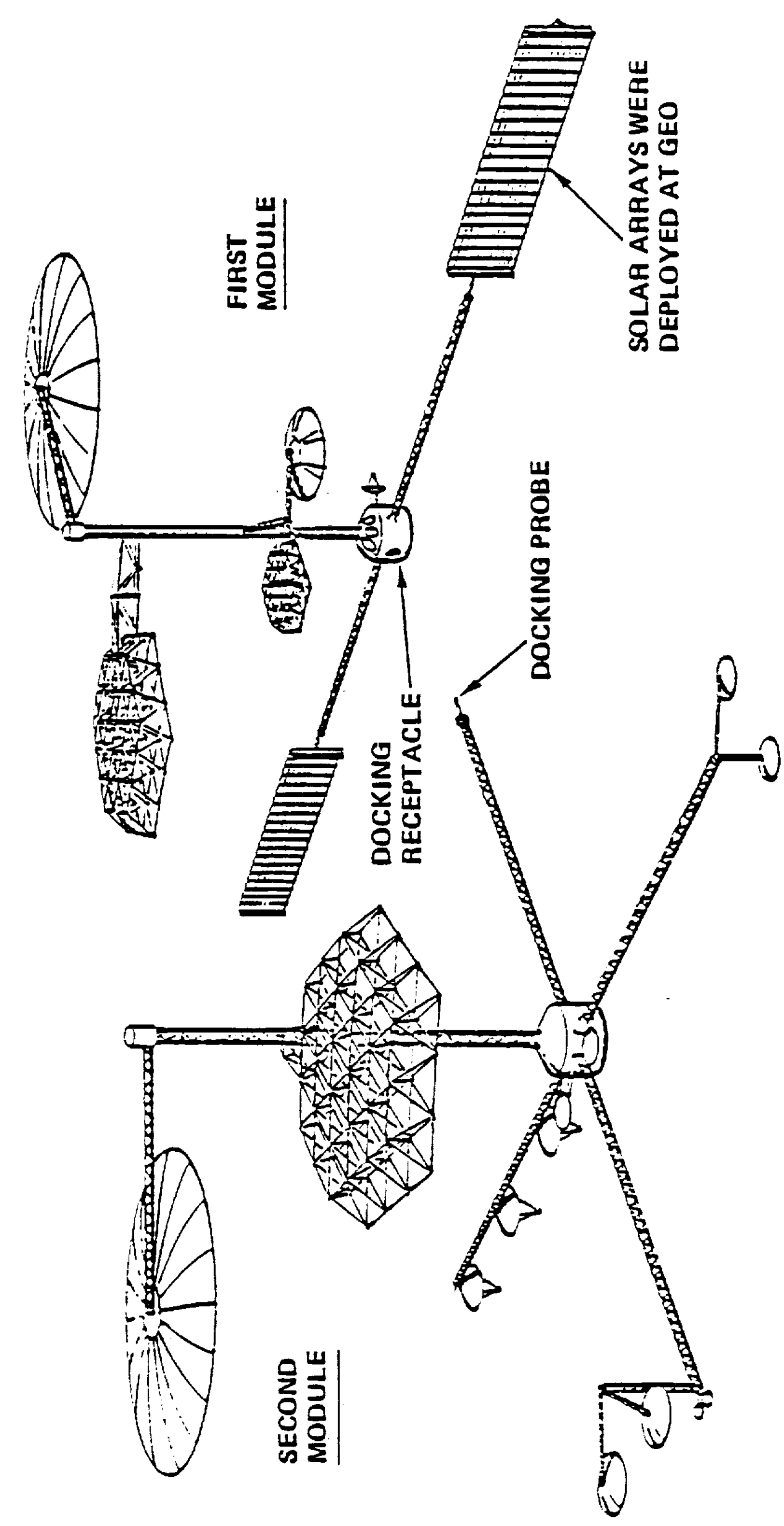

Figure 2-6. Orbital Docking Process of Two Modules for Alternative 2

The RIA Alternative 1 constellation of eight individual free flying modules is shown in Figure 2-7. Typical modules (platforms) and their payloads for this constellation are illustrated in Figure 2-8 (Module 1) and in Figures 2-9 and 2-10 (Module 2). Typical docked configurations (Alternative 2) are shown for AA-2 Slot 1 (Figure 2-11) and Slot 2 (Figure 2-12). Reference 2 presents a more detailed technical description of these platforms.

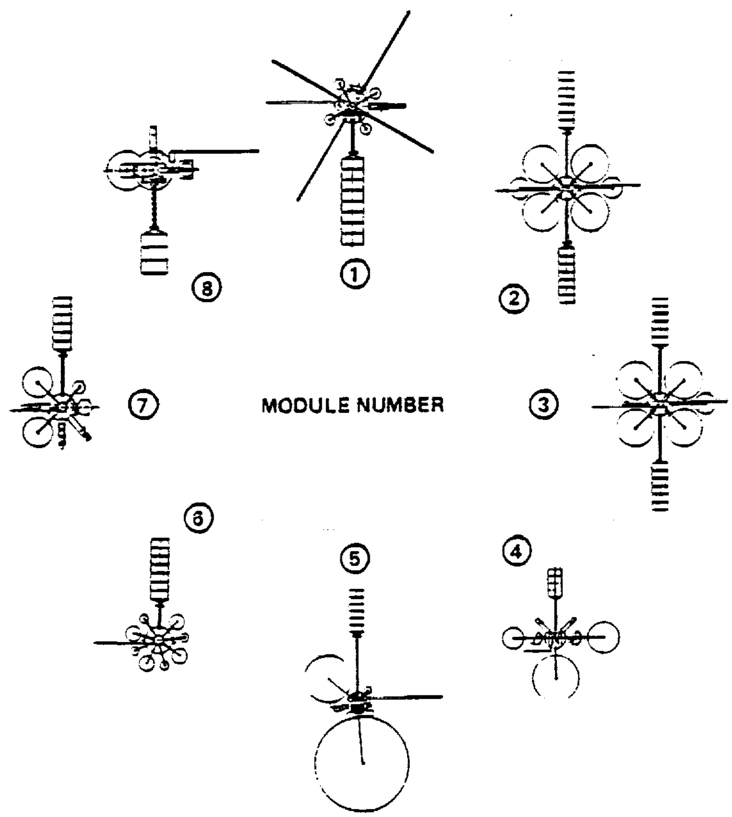

Figure 2-7. RIA Alternative 1 Constellation

The following paragraphs contain brief descriptions of the platform subsystems.

a. Primary Structure (WBS 1.1.1.1) - The primary structure of these platforms is a core module and several deployable or extendable support beams. The core module employs conventional skin-frame construction, including some composite materials, and houses the majority of the subsystem and payload equipment components. The deployable support beams are either Astromast or deployable truss designs and provide structural support and placement at the proper location for antennas, sensors, solar array panels, and other equipment not located in the core module. These beams are deployed automatically in LEO with man present for monitoring and corrective action if problems occur. There is no restowage capability included.

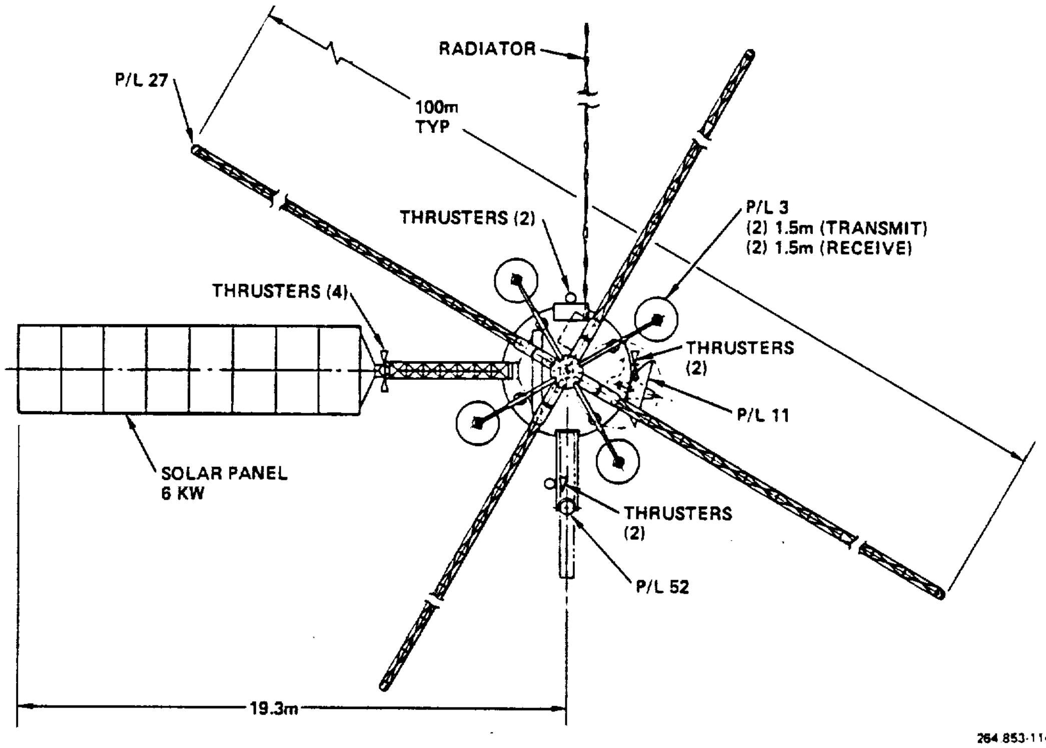

Figure 2-8. RIA Alternative 1, Module 1

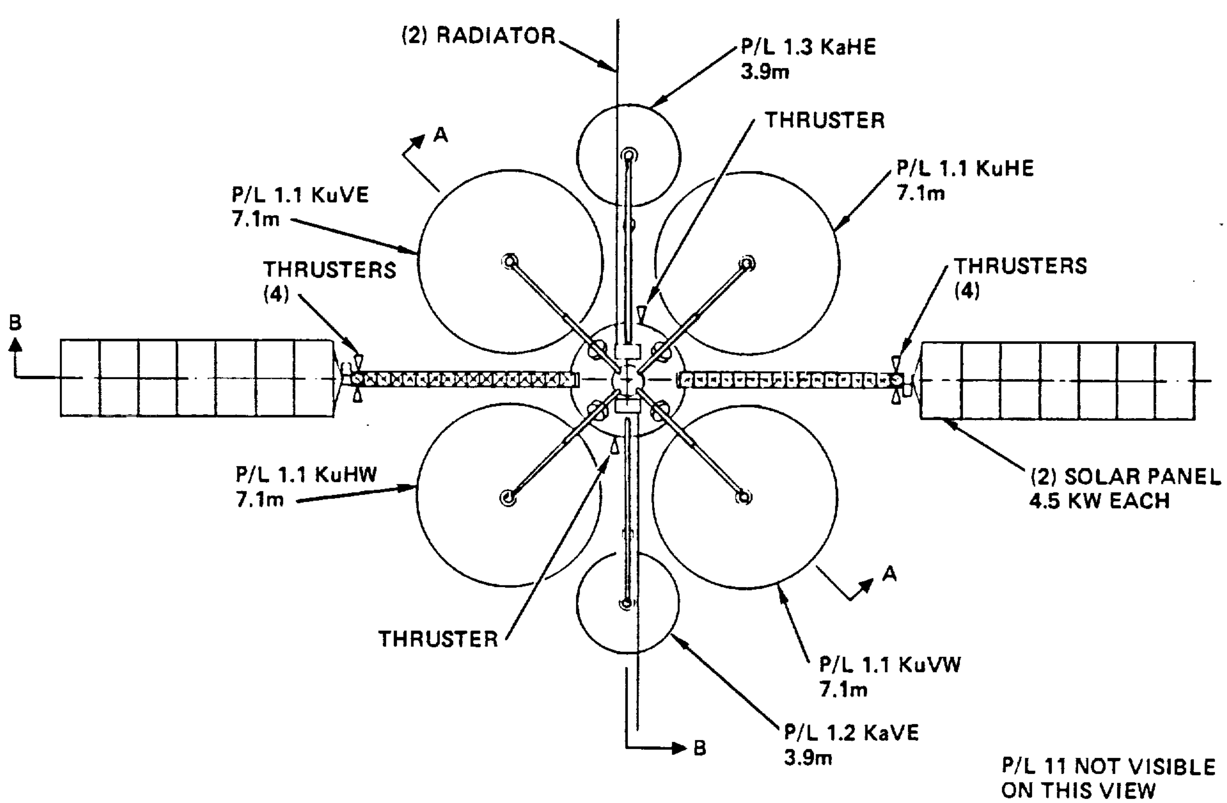

Figure 2-9. RIA Alternative 1, Module 2

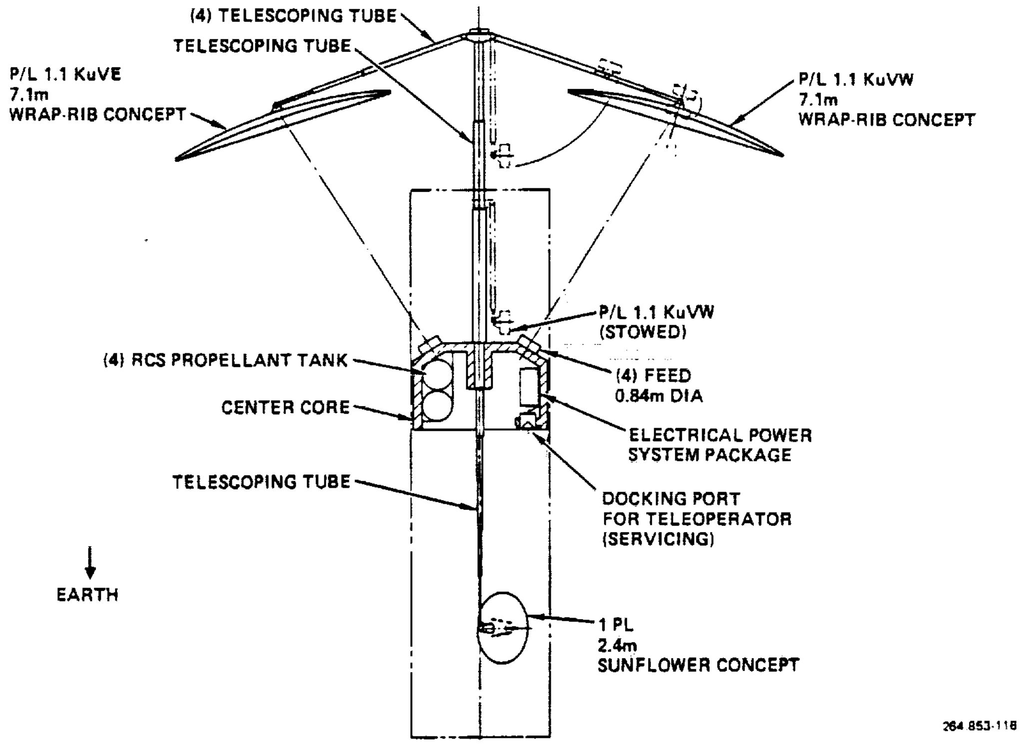

Figure 2-10. RIA Alternative 1, Module 2, Side View

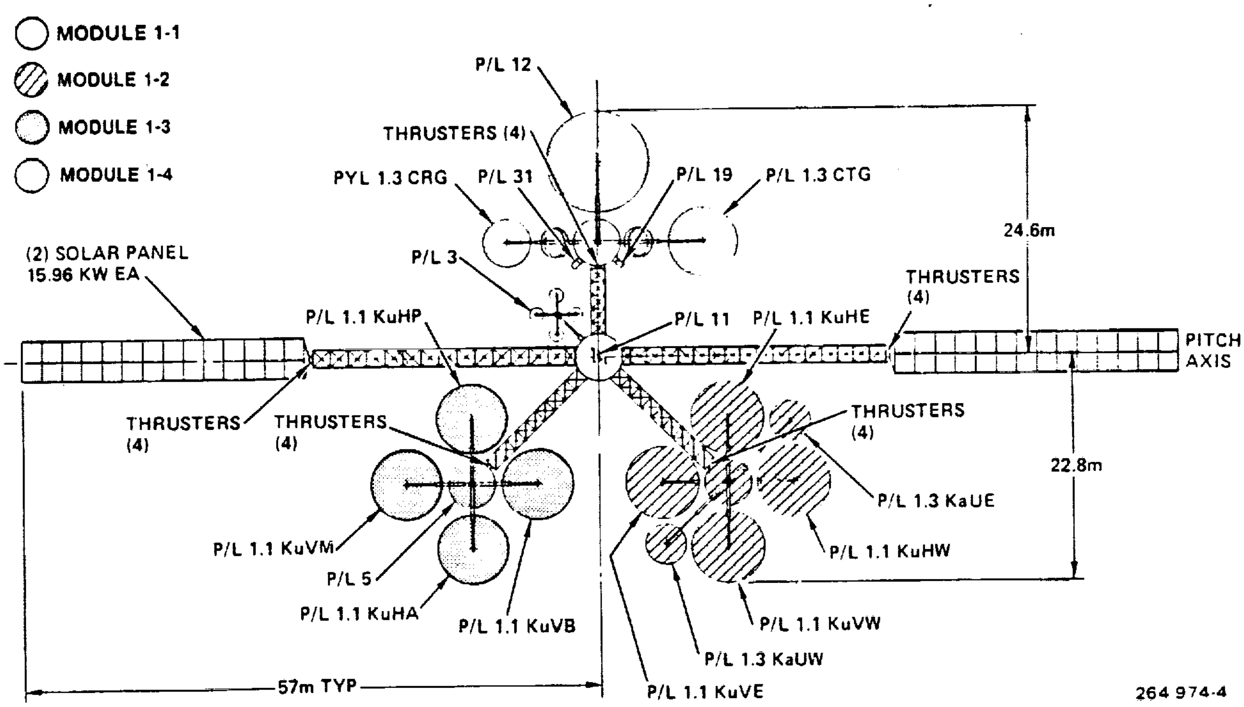

Figure 2-11. AA-2 Alternative 2 Platform (Slot 1)

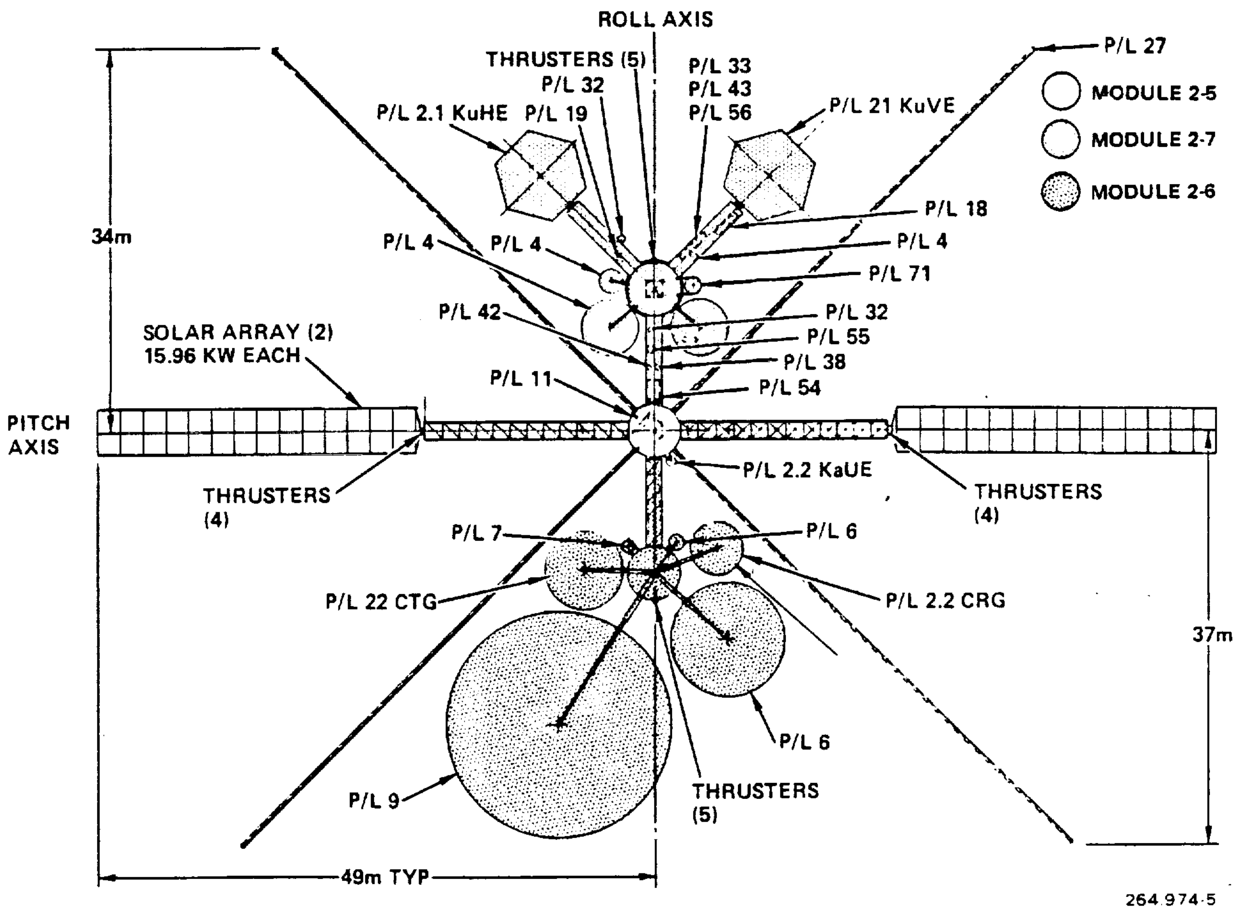

Figure 2-12. AA-2 Alternative 2 Platform (Slot 2)

The primary structure of each platform is different, depending on individual payload requirements. The weight of a typical structure is about 2500 pounds. Commonality is maximized, but the structure will exhibit some changes as the platform is tailored to its specific payload complement. It is assumed that both core and mast designs are modular to a major extent, to accommodate the different payload requirements and resulting design variations.

b. Secondary Structure (WBS 1.1.1.2) - The secondary structure associated with the platform consists of configuration-peculiar mounting bracketing, deployment arms and mechanisms, attachment fittings, nonload-bearing shielding, etc., necessary to accommodate the payloads and various subsystem equipment.

c. Thermal Control Subsystem (TCS) (WBS 1.1.2) - The TCS for these platforms consists of passive and semipassive components including coatings, insulation, louvers, heat pipes, cold plates, radiator panels, etc. There are no active (fluid heat transfer) systems in these concepts. The TCS weight is typically around 500 pounds, and is tailored to the requirements of each individual platform.

d. Attitude Control System (ACS) Avionics (WBS 1.1.3.1) - The ACS avionics consists of intelligence (computer, data processors), sensors (sun and earth sensors, star trackers, rate gyros, etc.), and their associated cabling and harness. These components provide attitude sensing, computation, and control signals to the AMCDs and RCS for platform attitude control and stabilization. Redundant units are provided as required to meet the necessary lifetime requirements. The ACS avionics for these platforms weighs 106.5 pounds and is generally common among the platforms.

e. Angular Momentum Control Devices (AMCD) (WBS 1.1.3.2) - The platform attitude control subsystem employs reaction wheel AMCDs to provide forces for stabilization and attitude control of the platform. These reaction wheels weigh 30.4 pounds each and have a momentum capacity of 70 ft-lb-sec. All platforms use seven of these AMCDs.

f. Reaction Control Subsystem (RCS) (WBS 1.1.4) - The RCS is used for attitude control, stationkeeping, and unloading the momentum wheels for these platforms. It is a conventional monopropellant (hydrazine) system consisting of pressurized bladder expulsion fuel tanks, helium pressure vessel, and four modular thruster assemblies. Each assembly has eight 1.65 lbm engines, each with 1.0 pounds of thrust. (These modules have dual redundant thrusters for a total of 32 thrusters per platform.) The total RCS dry weight is typically 400 pounds and is, in general, common between the platforms. Propellant capacity is variable, however, depending on the individual platform module requirements.

g. Electrical Power Subsystem (EPS) (WBS 1.1.5) - The EPS consists of:

1. a power generation system (primary power generation),
2. a power storage system,
3. a power management system (power conditioning and distribution).

The primary function of this subsystem is to provide properly conditioned electrical power to all other subsystems and to all required payloads and mission equipment carried in the flight vehicle.

h. Solar Array (WBS 1.1.5.1) - The power generation system consists of solar arrays made up of solar panels and their solar cells, all structures and supporting members, deployment and mechanism orientation devices, electrical busses, slipring assemblies, etc. The solar array generates the raw electrical power and routes it to the power conditioning and distribution system for use by the platform subsystems and payloads or storage in batteries. The solar arrays being considered use thin planar silicon cells with no concentrators. The array is assumed to be a modification or derivative of then-current technology and arrays. It is also assumed to be modular to the extent that the cells may readily be tailored to the individual platform power requirements. The gross beginning of life (BOL) power output of the required solar arrays varies from about 2 to 30 kWe depending on the individual platform requirements.

i. Batteries (WBS 1.1.5.2) - The energy storage portion of the electrical power subsystem consists of nickel-hydrogen batteries. Each platform has varying requirements for total energy storage capacity. The batteries are made up of 50 ampere-hour nickel-hydrogen cells. For example, a typical platform requires four battery modules each consisting of 72 cells. Each battery has an energy capacity of 2.63 kW-hr and weighs about 212 pounds; therefore, a typical platform energy capacity is 10.53 kW-hr and total weight is 848 pounds. The energy capacity for individual platforms is easily tailored because of the modular nature of these batteries.

j. Power Conditioning and Distribution (WBS 1.1.5.3) - The power conditioning subsystem consists of electronic components (power controllers, battery charger, inverters, converters, transformers, voltage regulators, protection systems, etc.) and an electrical power distribution system (power busses, all electrical cabling and harnesses, junction/distribution boxes, etc.). A typical weight for this subsystem is 640 pounds, but it will vary depending on the specific platform. Commonality at the component level is maintained among the platforms.

k. Tracking, Telemetry, and Command (TT&C) (WBS 1.1.6) - The TT&C subsystem consists of avionics equipment, and includes transmitters, receivers, transponders, antennas, instrumentation, sensors, decoders, multiplexers, other data processors and formatters, and cabling harnesses to provide for all ground link, platform, and payload housekeeping telemetry, command, and control, and platform tracking capability. Redundant units are provided as required for the necessary lifetime. The TT&C subsystem for these platforms weighs 106.5 pounds and is generally common among the platforms.

l. Rendezvous and Docking Avionics (WBS 1.1.7.1) - The rendezvous and docking system for Alternative 1 platforms is essentially a passive system providing a cooperative target for the TMS servicing flights. The equipment consists of laser retroreflectors, TV cameras (potentially), and an RF beacon. The weight allowance for these items is 68.5 pounds, and they are identical for all platforms. Alternative 2 (the docked configuration) requires active rendezvous and docking sensors (probably lasers), etc. Estimated weight of the equipment is 100 pounds for the active elements, and 12.7 pounds for the passive elements.

m. Rendezvous and Docking Mechanisms (WBS 1.1.7.2) - The mechanical components and mechanisms for the Alternative 1 platforms are limited to those necessary for cooperation with the TMS servicing vehicle. They may include probe, drogue, and locking mechanisms. The weight allocation for these items is 68.5 pounds, for all platforms. For Alternative 2 (the docked platforms) the active docking mechanical subsystem is estimated at 137 pounds and the passive element at 34.3 pounds.

n. Flight Support Equipment (FSE) (WBS 1.5) - The FSE hardware category includes all flight vehicle auxiliary equipment necessary to accommodate the payload in the Shuttle Orbiter, specifically structural supports or a cradle and all necessary interface equipment required during the launch to LEO, deployment, checkout, etc. This equipment remains with the Orbiter and is not part of the platform vehicle. The weight allowance for this FSE hardware is 1500 pounds and is assumed to be primarily structural in nature. It does not include cradles or deployment equipment associated with the OTV.

o. Payloads (WBS 1.2, 1.3, and 1.4) - The payloads for these platforms were previously identified and defined in Table 2-1.

The subsystem weights and other sizing and performance parameters that were used to drive the cost model are included on the cost output sheets for each of the platforms. These data are presented in Section 2.2.

2.2 COST ESTIMATES

This section documents the analysis conducted to refine and update the cost of geostationary platform systems estimated in Reference 1. It includes a discussion of the general methodology and the estimates for development, production, and operations.

2.2.1 METHODOLOGY AND GROUND RULES. The principal tool for generating cost information for trade studies during the study as well as for the final project cost estimate is a parametric cost model, Figure 2-13. This cost model, developed specifically for large platform-type spacecraft, generates costs parametrically at the subsystem level, using vehicle and program definition input data. The model also accepts direct inputs of point estimates at the level of detail available. This model and the overall methodology is discussed in more detail in Reference 1.

The Geostationary Platform System Work Breakdown Structure (WBS), Figure 2-14, provides the overall cost format and is used as a basis to identify cost elements to cover all costs expected to be incurred during the program. The WBS also sets the requirements for cost estimating relationships (CERs), cost factors, or point estimates. CERs are derived, based on an analysis of historical cost data and an analysis of cost driving parameters, for the range of technical approaches and performance parameters encountered in this program.

The model first derives a unit hardware cost or first unit cost. This unit hardware cost is then employed where necessary during the derivation of nonrecurring (development) costs and recurring (production and operation) costs. These are then accumulated appropriately to provide the required total program cost and the required levels of summarization.

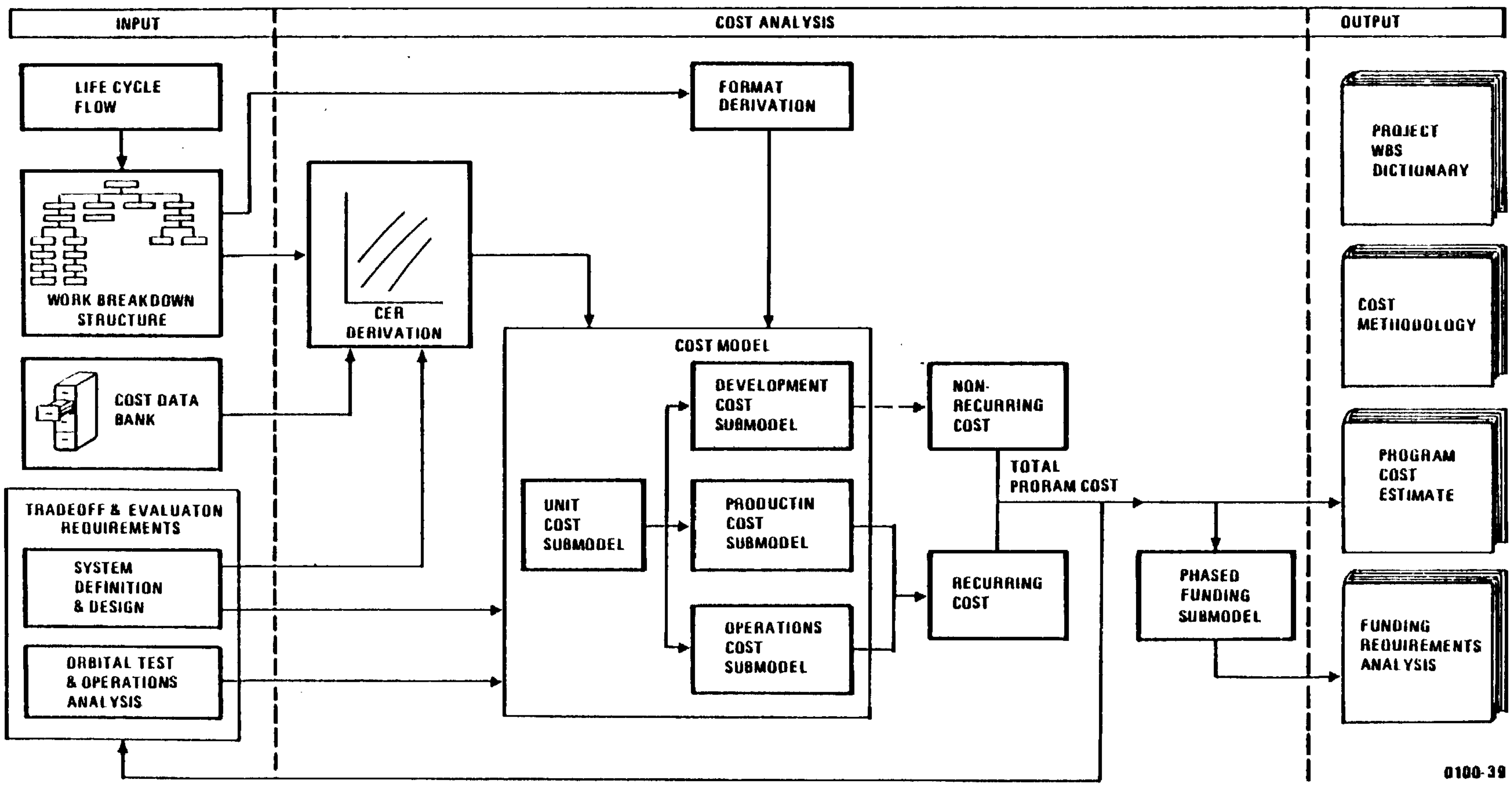

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Figure 2-13. Geostationary Platform Parametric Cost Model

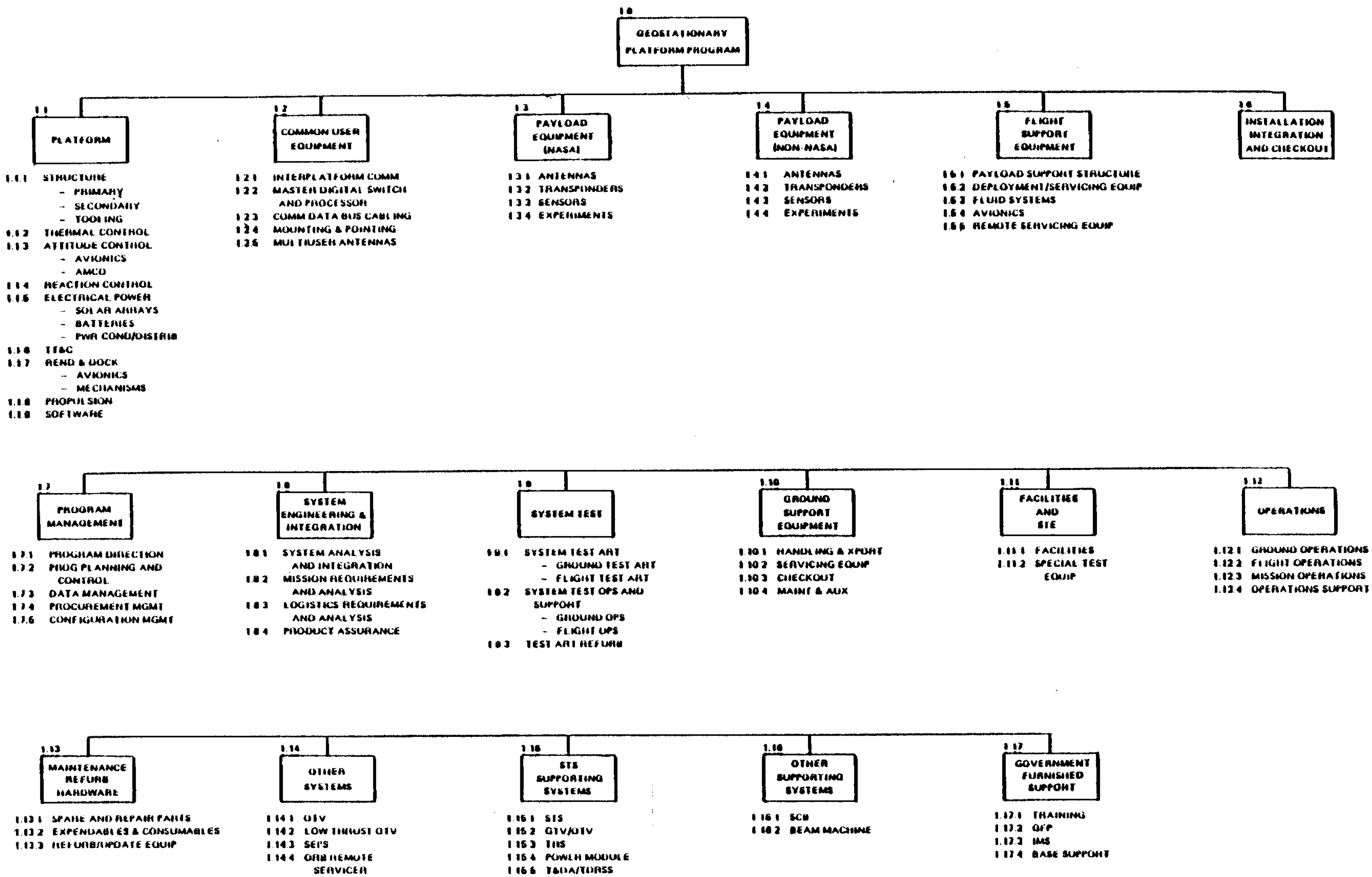

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Figure 2-14. Geostationary Platform System Work Breakdown Structure (WBS)

The following is a listing of the ground rules and assumptions that were followed in estimating the Geostationary Platform System costs reported herein.

a. Costs are estimated in current/constant FY 1981 dollars and reported by government fiscal year. No cost escalation or inflation is included. The FY 1981 dollar base was retained for consistency with the Initial Study.

b. Prime contractor fee is not included, however, subcontract fee is included as a cost to the prime.

c. Geostationary platform system costs are to include: nonrecurring development, recurring production, and recurring operations costs for both the platform and for payloads.

d. Costs attributable for the platform project only are to be segregated from the Geostationary Platform system level costs and from payload costs.

e. Costs for a platform control center facility and user ground stations facility for the operational period are excluded.

f. NASA Program Office and IMS costs are excluded.

g. This cost data is for planning purposes only.

2.2.2 PLATFORM MODULE COST ESTIMATES. Development, production, and operations cost estimates were prepared for the three operational geostationary platform systems. Detailed estimates are presented in Appendix A.

a. RIA Alternative 1 (8 Modules) Tables A-1 through A-16.

b. RIA Alternative 2 (6 Modules) Tables A-17 through A-28.

c. AA-2 Alternative 2 (7 Modules) Tables A-27 through A-42.

These estimates represent a reanalysis of the system concept and its cost that was documented in Reference 1. Only minor refinements of the cost model were necessary. The current study produced four approaches that encompass both a free-flying constellation (Alternative 1) and docked module platforms (Alternative 2) and two levels of communication technology, RIA and AA-2. New and refined technical designs were developed for each of these system concepts that would reflect a maximum of commonality within each concept. In these platform configurations, however, the requirements of the specific payloads that are carried, exert a very strong influence on the design of the platform, especially the physical configuration necessary to accommodate the wide variety of antennas, etc. Because of this situation, it is expected that all platforms will be tailored to the payloads in a greater or lesser degree. As a result "nonrecurring development" costs are incurred for each platform module. Because these costs are generally one-time only, they are identified as development. Theoretically, if more than one of the particular platform costs were produced, those costs could not be incurred again. The sequence assumed for the development, fabrication, and launchings are identical with the module identification number. The development costs reflect this same sequence.

It is assumed the technology level associated with these platforms is the level available in the 1990s time period. Off-the-shelf hardware, standard components and assemblies, and available technology will be used wherever possible, consistent with the stipulation that lifetime will be a principal consideration. A certain amount of advanced technology development is foreseen as a requirement for the subsystems, particularly the long life requirements imposed upon the functional hardware. The impact of these lifetime requirements on the hardware, beyond redundancy, has not been determined. Certain costing assumptions have been made, however, to take this into account in a general across-the-board manner and therefore make consistent cost allowances for long-life requirements.

Payload costs were generated in a very general manner to determine the overall magnitude of the total program. These estimates were made with top level CERs that were not responsive to individual communication payload differences in complexity but, when accumulated into total program cost, will provide reasonable aggregated total program cost estimates. Experiment payloads were estimated separately from the communications payloads to reflect the differing complexity and lifeline requirements. No attempt was made to identify already developed or existing payloads for cost adjustment thereof.

The system definition and input data were obtained from several sources. The platforms are briefly described in Section 2.1 of this volume and defined in detail in Reference 2. The payloads are also described in Reference 2 and the assignment of the payloads is summarized in Table 2-3, 2-4, and 2-5, herein. Applicable program schedules both for individual platforms as well as the overall system are included in Reference 1. The Work Breakdown Structure (WBS) tree for the geostationary platform system is shown in Figure 2-14 and presented in detail in Section 5 of Reference 1 in the form of a WBS dictionary.

As may be seen in the subsequent platform cost estimate tables, the costs are identified between a) the platform-only tasks and hardware, and b) the payloads and system-level costs. Any cost not reasonably allocatable to either platform or payload was allocated to the system level. This was done to segregate and make available the cost of a platform-only project.

The costs associated with each module of a system are presented on two pages. The first page contains a printout of the cost model run for the platform module itself without payloads or system level costs. The second page includes the platform module total cost, the cost of the individual payloads, and the system level integration costs associated with each of the individual modules.

The platform costs for nonrecurring development and for unit production are presented for the flight vehicle module at the subsystem level together with other "wraparound" cost elements. In addition, the sizing parameter that is used to drive the cost model is included for each subsystem. The parameters are all in weight (pounds) except for a) the reaction wheel subsystem parameter which is in foot-pound-seconds (angular momentum capacity), b) the solar array (EPS-Solar Array) parameter which is in kilowatts of power (gross output at beginning of life), c) the NiH_2 battery parameter which is in kilowatt hours (total energy capacity) and d) the software which is in terms of number of lines of instruction.

The commonality factor for each cost element is shown and indicates the extent of additional development incurred in terms of percent of new effort, considering the work already accomplished on prior module developments. In the case of RIA Module No. 1 (App. A, Table A-1), all commonality factors are 1.00 (i.e., 100 percent new) since this is the initial module developed. RIA Module No. 2 (App. A, Table A-3), however, shows the varying commonality impact on the development cost. For instance, the structure subsystem assessment indicates that a 22 percent additional effort is required to provide new or changed primary structure over and above the development already accomplished on Module No. 1 primary structure. Similarly, the thermal control subsystem requires an additional 50 percent of development effort to tailor this platform module thermal control to the specific payload assigned to it.

2.2.2.1 Development Cost. The nonrecurring development cost for platform modules is shown for each WBS element. These development costs include all hardware and software design and analysis, hardware fabrication for component and assembly level development tests, and qualification testing thereof. The cost includes the system engineering and integration, system level test articles and test operations, GSE and FSE, facilities, and lastly, program management.

Platform subsystem hardware costs were estimated with CERs appropriate to the technology family and hardware complexity involved. Two basic CER adjustments that were originated for the early trade study model were retained for this model and its estimate. The first of these adjustments is applicable to avionics and nonstructural dynamic mechanisms. It adds a fixed percentage override on development costs to account for additional cost due to long (16 year) lifetime systems requirements. This is in addition to increased costs resulting from increased weight estimates because of redundancy, etc. The trade studies looked at 8-year and 16-year systems. The 16-year system required cost adjustment and was therefore applied to all long-life costs. The second adjustment was to decrease the sensitivity (slope) of avionics development CERs to weight for these long-life systems. This was done because all of the long-life systems considered herein have a very high degree of redundancy and if only based on weight, the CER would not properly reflect the true (lesser) degree of development complexity. For example, where the weight estimate includes three redundant units, only one unit need be designed and tested. It is recognized that some additional cost for redundancy management is required. Example subsystem costs based on component level estimates were used to derive a reduced sensitivity slope for these CERs.

No platform software definition was available, therefore, only a gross estimate was made of the number of words of instruction required for flight software. Further analysis is required to refine the resulting cost estimates.

Most of the "wraparound" costs (System Engineering and Integration, GSE, Initial Spares, and Program Management) are estimated using cost factors, i.e., a percentage of the basic hardware development cost. All GSE cost (design development, test and production) and FSE costs will be included as a one-time nonrecurring development cost.

System level test article hardware costs were estimated based on 1.75 equivalent units of hardware being required. The unit cost of this hardware includes a set of platform hardware, less 75 percent of the solar array cost, plus 50 percent of the IA&C/O, plus the sustaining engineering (SE&I) cost during the fabrication. Test operations costs are based on test article hardware value.

The payload development costs were estimated at a top level only. Consideration was also given to multichannel equipment whose hardware fabrication is highly repetitive, for example, equipment consisting of many identical transponders. Noncommunications payloads (experiments) were evaluated as to lifetime, i.e., some experiments are not required to have a 16-year lifetime, and costs were estimated appropriately.

At the geostationary platform system level, wraparound costs for SE&I and for the system level tests are again based on hardware development costs. The system level test article consists of the existing Payload Integration Test Article (PITA) from the platform development program, plus one full set prototype payloads from the payload development programs. Cost for the latter are estimated at 20 percent of new items to cover refurbishment to the system test configuration. In addition IA&C/O is added for total (incremental) test article cost. Estimates of test operations are, however, based on equivalent cost of an all-up set of new test hardware. The geostationary platform integration facility funded under the platform program will also be used for geostationary platform system-level testing.

It is assumed that payload GSE and FSE is included in the payload development cost.

2.2.2.2 Production Cost. Production costs include all component and subsystem procurement, parts fabrication, subassembly and subassembly checkout, final assembly (subassembly installation and integration), final assembly checkout, and the acceptance test procedures resulting in customer selloff via DD250. They also include all quality control (inspection) procedures as well as program management activities necessary for procurement and subcontract control as well as production control of the prime contractor.

Platform subsystem hardware costs were estimated with CERs appropriate for the technology family and hardware complexity associated with this flight vehicle. As with the development CERs, an adjustment was made to the production CERs to reflect an increased cost of the 16 year long-life hardware. As with the development cost adjustment, it is over and above the additional cost due to increased weight for the redundancy associated with long life.

Wraparound cost factors for final assembly, installation and checkout (including acceptance testing), and program management are based on hardware production costs. The production cost appearing in the SE&I cost element represents sustaining engineering during the production process and is estimated in the same manner as the other wraparounds.

No cost improvement as a result of learning was considered because of the low production quantity involved and the fact that platform modules are all different to a greater or less degree. A more refined approach should look at subsystems-level learning across the entire geostationary platform program where a significant quantity of common subsystem equipment is used.

The costs are segregated by those incurred for the platform only, and those associated with the payloads and system level activities.

2.2.2.3 Operations Costs. The recurring operations cost estimates are summarized in Table 2-6 for the three different operational activities: 1) the initial platform placement flight, 2) a platform servicing flight, and 3) the sustaining on-going mission operations period. These operational costs are discussed in detail in Reference 1. Again, costs are split between those incurred solely by the platform and those attributable only to the overall geostationary platform system (or the payloads themselves) where they could be reasonably allocated. The STS user charges included are those associated with the first three years of operations in lieu of an official estimate of the post 1986 period. It is expected, however, that the reimbursement charge for shuttle transportation in the geostationary platform operational period will be substantially increased.

2.3 COST SUMMARIES

Cost summaries for each of the three system concepts are shown in Tables 2-7 through 2-9. The results are presented for each platform module, its placement flight and servicing flights, and for platform operations. Costs are shown for the platform development and flight unit production, and similarly for the payloads and system level hardware and effort. Operations costs for each placement flight are shown under operations, but servicing flight costs and platform mission operating costs are not allocated to individual platforms.

The three concepts that were examined in detail are compared in Table 2-10. The fourth combination, AA-2 Alternative 1, was not estimated in detail; top level costs were obtained by extrapolation from the data developed for the other three concepts.

The summary excludes mission operations costs. The Alternative 2 concepts (docked modules) are the lowest in cost, with the RIA being the lowest, followed by AA-2. The RIA payloads have a cost advantage because of the less advanced state of the payload communications technology. If one disregards the payloads and their cost uncertainties, and considers the platforms alone, both Alternative 2 cases (docked platforms) incur about the same cost, which is less than both

Table 2-6. Operations Costs

WBS	Cost Element	Initial Placement (Per Flt)		Servicing Flight (Per Flt)		MSN Sup (Per Yr Full Sys)	
		PLAT	GP/PL	PLAT	GP/PL	PLAT	GP/PL
1.12.1	Ground Operations	.07	.32	.02	—	—	—
	Transportation	(.07)	—	*	—	—	—
	Offline Prep/CITE	—	(.27)	.01	—	—	—
	On Line STS Install/Integ	—	(.02)	*	—	—	—
	Launch OPS Support	—	(.01)	*	—	—	—
	Post Mission Ops	—	(.02)	0	—	—	—
1.12.2	Flight Operations	—	.37	.03	—	—	—
	P/L Specialist	—	(.05)	(0)	—	—	—
	MSN/PL Specialist Training	—	(.20)	(0)	—	—	—
	POCC Ops	—	(.12)	(.03)			
	Prep	—	(.03)	(*)	—	—	—
	Launch/Activation	—	(.04)	(.02)	—	—	—
	Data	—	(.05)	(*)	—	—	—
1.12.3	Mission Operations	—	TBD	—	—	2.10	TBD
	Platform Ops	—	—	—	—	(1.50)	—
	Platform Data	—	—	—	—	(.60)	—
	User Gnd Sta/Ops	—	TBD	—	—	—	TBD
1.12.4	Operations Support (Contractor)	.24	.16	.16	—	(.73)	TBD
	Flt Ops Support/Plng	(.24)	(.12)	(.11)	—	—	—
	Msn Ops Support/Plng	—	—	—	—	(.73)	TBD
	Logistics Support/Plng	—	(.04)	(.05)	—	—	—
1.13	Maintenance & Refurb/Update Hardware	.01	0	1.73	0	—	—
1.13.1	Spare & Repair Parts	(0)	(0)	(0)	(0)	—	—
1.13.2	Expendables/Consumables	(.01)	—	(.01)	—	—	—
1.13.3	Update Replacement Equipment						
	Propellant Tanks (3)	—	—	(.72)	—	—	—
	Batteries (4)	—	—	(1.00)	—	—	—
1.15	STS/Support Sys	—	69.41	—	39.00	—	—
1.15.1	STS	—	(33.41)	—	(32.00)	—	—
	Basis	—	(32.00)	—	(32.00)	—	—
	Add Stay Time	—	(1.10)	—	(0)	—	—
	EVA	—	(.16)	—	(0)	—	—
	RMS	—	(.15)				
1.15.2	OTV	—	(36.00)	—	(5.00)	—	—
1.15.4	TMS	—	—	—	(2.0)	—	—
1.15.5	T/DA-TDRSS	—	TBD	—	TBD	—	TBD
	Total	.32	70.26	1.94	39.00	2.83	TBD

*Less than $5k

cases of Alternative 1 (free flying constellation). This is primarily due to the lesser number of modules required, the service flights, and the transportation. These advantages become even more pronounced if one considers a more realistic shuttle transportation user charge expected in the operational time period.

Table 2-7. RIA Alternative 1 Operational System Cost Summary (1981 M$)

Platform	Platform Cost Dev	Platform Cost Prod	Payload Cost Dev	Payload Cost Prod	System Cost Dev	System Cost Prod	Operations Cost	Total
1	338.7	49.7	115.1	58.6	19.3	2.4	79.0	662.8
2	61.7	58.6	112.6	130.6	31.3	5.4	79.0	479.2
3	36.5	51.6	71.4	119.4	26.1	5.0	79.0	389.0
4	34.2	38.4	125.1	76.2	22.8	3.2	79.0	378.9
5	37.3	57.2	93.4	70.3	19.5	2.9	79.0	359.6
6	22.4	31.2	39.2	54.2	12.4	2.3	79.0	240.7
7	17.8	39.8	161.0	71.6	25.2	3.0	79.0	397.4
8	16.9	39.1	94.9	48.6	15.9	2.0	79.0	296.4
Total	565.5	365.6	812.7	629.5	172.5	26.2	632.0	3204.0
Service Flights (11)								506.0
Mission Operations (Platform Only)								41.3
Grand Total								$3751.3M

Table 2-8. RIA Alternative 2 Operational System Cost Summary (1981 M$)

Platform	Platform Cost Dev	Platform Cost Prod	Payload Cost Dev	Payload Cost Prod	System Cost Dev	System Cost Prod	Operations Cost	Total
1	497.1	90.3	56.6	29.8	9.7	1.2	79.0	763.7
2	43.4	18.7	169.3	120.1	34.1	5.0	79.0	469.6
3	20.2	17.9	86.5	83.5	21.2	3.5	79.0	311.8
4	17.6	18.9	207.1	95.8	33.1	4.0	79.0	455.5
5	43.9	87.7	53.2	12.5	6.4	.5	79.0	283.2
6	23.7	19.4	217.6	106.8	35.8	4.4	79.0	486.7
Total	645.9	252.9	790.3	448.5	140.3	18.6	474.0	2770.5
Service Flights (7)								322.0
Mission Ops (Platform only)								41.3
Grand Total								3133.8

Table 2-9. AA-2 Alternative 2 Operational System Cost Summary (1981 M$)

Platform Module	Platform Cost Dev	Platform Cost Prod	Payload Cost Dev	Payload Cost Prod	System Cost Dev	System Cost Prod	Operations Cost	Total
1-1	494.7	88.2	79.0	51.4	15.1	2.1	79.0	809.5
1-2	46.5	18.7	102.7	105.5	26.2	4.4	79.0	383.0
1-3	15.7	17.5	66.5	71.9	17.6	3.0	79.0	271.2
1-4	17.2	18.6	121.5	51.5	18.6	2.1	79.0	308.5
2-1	48.2	90.4	23.8	41.9	9.1	1.7	79.0	294.1
2-2	23.7	19.3	153.1	85.3	26.9	3.5	79.0	390.8
2-3	15.0	18.6	294.9	99.6	40.8	4.1	79.0	552.0
Total	661.0	271.3	841.5	507.1	154.3	20.9	553.0	3009.1
Service Flights (9)								414.0
Mission Operations (Platform only)								41.3
Grand Total								3464.4

Table 2-10. Operational Geostationary Platform Concepts Cost Comparisons (1981 M$)

Architecture	RIA (One Slot)				AA-2 (Two Slots)			
Alternative No.		1		2		1		2
No. of Transportation Flights		8		6		10		7
No. of Servicing Flights		11		7		14		9
Bus Costs								
Development	566		646		621		661	
Production	366		263		457		271	
Total Bus Costs		932		899		1078		932
Payload & System Costs								
Development	986		931		1026		996	
Production	656		467		714		528	
Total P/L Costs		1642		1398		1740		1524
Transportation Costs								
Delivery Flights	632		474		790		553	
Logistics Flights	506		322		644		414	
Total Transp. Costs		1138		796		1434		967
Total Program Costs		3712		3093		4252		3423
Total W/O Payload		2070		1695		2512		1899

SECTION 3
EXPERIMENTAL PLATFORM

The Initial Study and the first part of the current effort concentrated on system concepts for an operational system of the 1990s. The latter part of the current study concerns a precursor experimental platform concept to demonstrate and validate the approach adopted for the operational system by means of actual orbital flight testing. This section summarizes the cost and schedule analysis work accomplished to date. The results are preliminary because of the conceptual nature of the experimental platform definition. More refined cost estimates will be possible during the planned follow-on study effort, as the design definition is finalized and detailed.

3.1 EXPERIMENTAL PLATFORM DESCRIPTION

In the Initial Geostationary Platform Study, as operational concepts and the corollary technology requirements began to emerge, NASA/MSFC anticipated the need for an experimental geostationary platform to demonstrate the advanced technologies, systems, and use modes required to pave the way for the operational platforms of the 1990s. These technologies should be demonstrated early in the geostationary platform program to verify concept feasibility and justify further program planning.

As presently conceived, the experimental platform would be placed in geostationary orbit in about 1989, probably over the Western Hemisphere at about 110 degrees west. Upon completion of experiments and demonstrations relevant to CONUS interests, the platform could be moved to an Atlantic position (15 degrees west) for continuation of demonstrations and validations related to international communications systems. Such planning is flexible and dependent on the ultimate choice of payloads selected for this platform during the Phase B Definition Study. Payloads would be limited to those that could be accommodated by the platform in a single Shuttle flight, and that would demonstrate technologies that were feasible, practicable, promised the greatest benefit overall, and that involved technical risks sufficiently above current satellite technology to warrant the use of public funds.

The primary objectives in placing an experimental geostationary platform in orbit will be to:

a. Demonstrate the technologies, systems, and uses necessary to pave the way for operational geostationary platforms of the 1990s.

b. Provide an opportunity to test new communications technologies and services.

c. Provide an opportunity for science and applications experiments.

In attaining these objectives, the platform must clearly demonstrate a significant step toward operational systems in both payload and platform technologies, systems, and uses. Communications experiments should be directed toward more efficient use of the frequency spectrum, increased capacity, new services, and greater hardware capability. Platform experiments should demonstrate better packaging and deployment techniques, structural advances, modular buildup, servicing, orbital transfer techniques, and rendezvous and docking technology.

Successful proofing by the experimental platform of advanced communications systems and technologies and of platform deployment assembly and control technologies would enable inclusion of such approaches in the design of the 1990 era operational platforms, ultimately relieving the geostationary orbital arc and spectrum saturation problems, and lowering communications costs to the user.

The Experimental Platform concept evolved and selected in Task 9 for this study, described briefly below, serves as a basis for the subsequent cost estimates. This platform is more fully described in Volume II of the Final Report (Reference 2).

The payloads selected for the Experimental Platform are as follows:

203 - UHF Technology Demonstration	466 kg*
601 - 6/4 Technology Demonstration	453 kg
502 - Data Collection System (DCS)	50 kg
501 - VAS	79 kg
401 - Lightning Mapper	140 kg
301 - Imaging Spectrometric Observatory	228 kg
123 - Environmental Effects on Space Systems	30 kg
122 - Sheath, Wake, & Charging Studies	46 kg
604 - Interplatform Link	100 kg
116 - High Performance N.S. Stationkeeping	—

*Includes the common 15-meter transmitter antenna for payloads 203 and 601.

The overall platform configuration is shown in Figures 3-1 and 3-2.

In this concept, the active antenna elements (feed arrays) are hard-mounted to the central core, simplifying the problems associated with mounting and wiring large feeds through a deployable mast. To minimize the packaging of large offset antennas, the Lockheed "wrapped-rib" concept is used. In addition, a 15m common transmit antenna is used for both P/L 203 and 601. The 10m antenna is located off the E-W axis to provide an optimum location for the radiator. The GDC deployable-boom concept (triangular cross-section) is used to support the solar arrays (Lockheed "SEPS" type concept). The remainder of the payloads are mounted on three semi-deployable type structures (GDC "space rail" concept). The platform is essentially constructed of graphite-epoxy composites to meet the requirements of a thermally stable structure.

A section through Payloads 203 and 601 (Figure 3-2) shows the relative geometry of the direct offset antennas. The large feed arrays (95 inches for the 15m and 60 inches for the 10m) are hard-mounted to the central core structure. The central mast supporting the two antennas is the GDC deployable truss concept (diamond

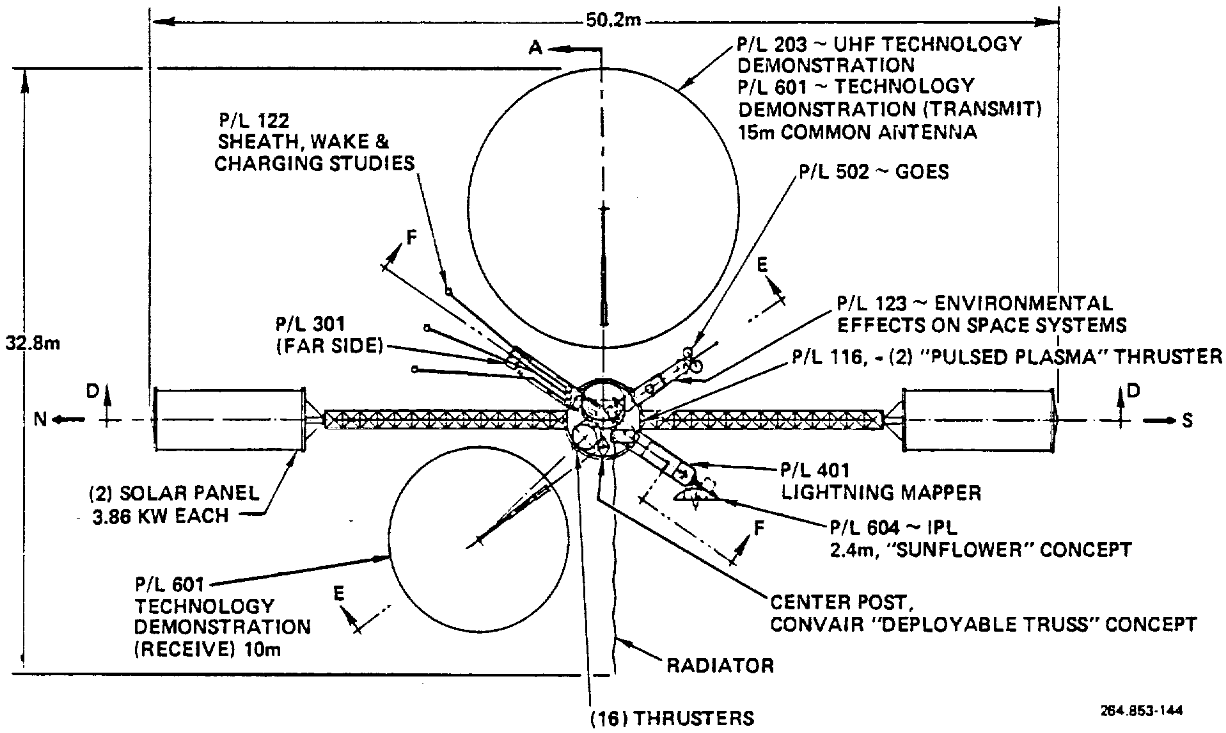

Figure 3-1. Experimental Platform Plan View

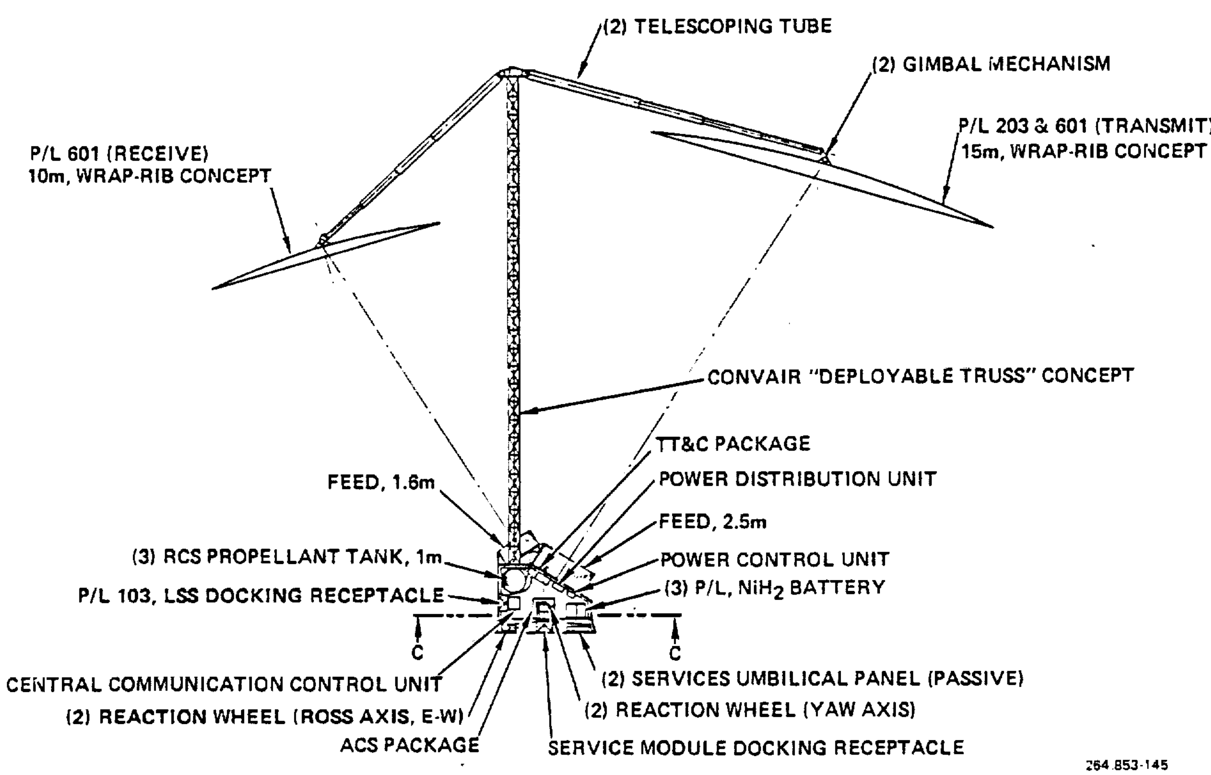

Figure 3-2. Experimental Platform Side View

cross-section) currently under development. All subsystems are mounted within the central core structure. Three hydrazine propellant tanks and six battery packs (3 batteries) provide a seven-year life for the platform. Incorporated within the central core structure is a docking cone for the LSS docking equipment, a docking cone for the soft docking system employing a single-point probe used on the service module, and dual redundant umbilical interface panels for the servicing operation.

All subsystems are located within the central core structure (Figure 3-3) and can be hard-wired, plumbed, etc., during initial fabrication. They can be checked out on the ground, minimizing checkout operations in LEO. Access panels can be provided on the central core structure for those components requiring repair or replacement during initial assembly.

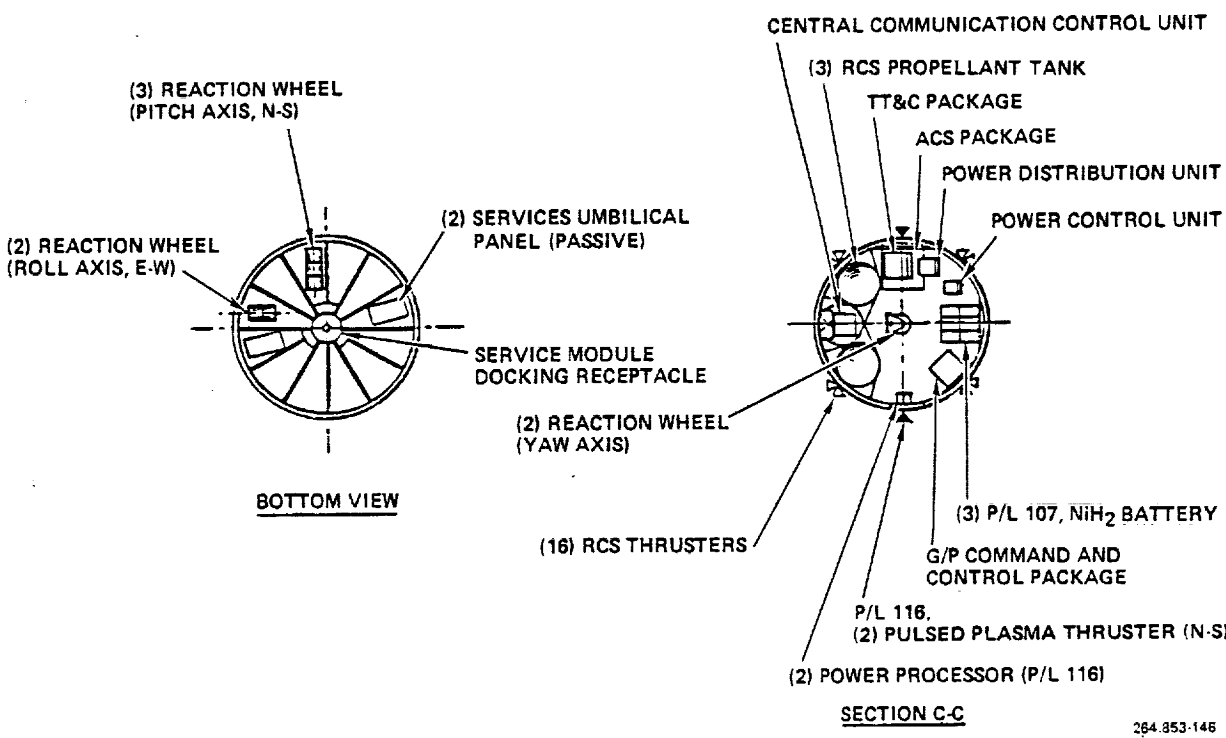

Figure 3-3. Core Module Cross-Section

A brief description of each of the platform subsystems follows.

a. Primary Structure. The primary structure of this platform is made up of a core module and several deployable or extendable support beams. The core module employs conventional skin-frame construction, with some composite materials, and houses the majority of the subsystem and payload equipment components. The three deployable support beams are GDC deployable truss designs and provide structural support and placement at the proper location for antennas, solar array panels, and other equipment not located in the core module. Telescoping tubes provide deployable antenna mounting. These deployable elements are extended automatically in low earth orbit with man present for monitoring and corrective action in case of problems. There is no restowage capability included. The primary structural elements for this platform weigh 2070.5 lbs.

b. Secondary Structure. The secondary structure associated with the platform consists of mounting brackets, deployment arms and mechanisms, attachment fittings, nonload-bearing shielding, etc., necessary to accommodate the subsystem equipment and payloads. The secondary structural weight used is 193.2 lbs.

c. Thermal Control Subsystem (TCS). The TCS consists of passive and semi-passive components including coatings, insulation, louvers, heat pipes, cold plates, radiator panels, etc. The TCS for this platform weighs 461.5 lbs.

d. Attitude Control System Avionics. The attitude control system (ACS) avionics consists of intelligence (control processing electronics), sensors (sun and earth sensors, rate gyros, etc.), and the associated cabling and harness. These components provide attitude sensing, computation, and control signals to the AMCDs and RCS for platform attitude control and stabilization and stationkeeping. Redundant units are provided as required to meet the necessary lifetime requirements. The ACS avionics for this platform weighs 77 pounds.

e. Angular Momentum Control Devices (AMCD). The platform attitude control subsystem employs seven reaction wheels to provide control forces for stabilization and attitude control of the platform. These reaction wheels weigh 30.4 pounds each and have a momentum capacity of 74.8 ft-lb-sec.

f. Reaction Control Subsystem (RCS). The RCS used for unloading the momentum wheels is a conventional current-technology monopropellant (N_2H_4) system consisting of three pressurized bladder expulsion fuel tanks, and four modular thruster assemblies. Each assembly has four thrusters of 0.1 pound thrust each. Each fuel tank is 50 inches in diameter and contains 575 pounds of hydrazine. Two pulsed plasma thrusters are mounted on the N-S axis of the central core structure to provide high performance station keeping (Payload 116). The total RCS dry weight is 399.4 pounds.

g. Electrical Power Subsystem. The EPS consists of:

1. a power generation system (primary power generation),
2. a power storage system, and
3. a power management system (power conditioning and distribution).

The primary function of the power subsystem is to provide properly conditioned electrical power to all other subsystems and to all required payloads and mission equipment carried in the flight vehicle.

h. Solar Array. The power generation system consists of solar arrays made up of solar panels and their solar cells, all structures and supporting members, deployment devices and mechanisms, orientation devices, electrical buses on the array, bearing and power transfer assembly (BAPTA), etc. The solar array generates the raw electrical power and provides it to the power conditioning and distribution system and hence to either the power storage system or the platform subsystems and payloads. The solar arrays being considered use high efficiency (14 percent AMO) thin planar silicon cells with no concentration. The array is assumed to be a derivative of the late 1980s type technology or other already developed array. The gross beginning of life (BOL) power output of the required solar array is 7.7 kWe for this platform. The solar array weighs 566 pounds and has 450 sq feet of cells.

i. Batteries. The energy storage portion of the electrical power subsystem consists of nickel hydrogen batteries. Each platform has varying requirements for total energy storage capacity. These batteries are made up of 50 ampere-hour nickel hydrogen cells. The experimental platform requires three battery modules each consisting of 48 cells. Each battery has an energy capacity of 2.4 kW-hr and weighs about 163 pounds, therefore, the platform energy capacity is 7.2 kW-hr and the total weight of 489.5 pounds.

j. Power Conditioning and Distribution. The power conditioning subsystem is a high frequency AC (20 KHZ) high voltage (500 volt) system. It consists of electronic components (power controllers, protection systems, battery charger, inverters, converters, voltage regulators, etc.) and an electrical power distribution system (power buses, all electrical cabling and harnesses, junction/distribution boxes, etc.). The weight of this subsystem is 255.9 pounds for this platform.

k. Tracking, Telemetry, and Command (TT&C). The tracking, telemetry, and command subsystem consists of avionics equipment such as the STDN transponders, antennas, instrumentation and sensors, decoders, multiplexers, and other data processors or data formatters, etc., and cabling harnesses to provide for all ground link, platform, and payload housekeeping telemetry, command and control, and platform tracking capability. Redundant units are provided as required for the necessary lifetime. The TT&C subsystem weighs 195.3 pounds for this platform.

l. Rendezvous and Docking Avionics. The rendezvous and docking system is essentially a passive system providing a cooperative target for the TMS servicing flights. The equipment consists of laser retroreflectors and potentially an RF beacon. The weight allowance for these items is 13.5 pounds.

m. Rendezvous and Docking Mechanisms. The mechanical components and mechanisms for the experimental platform are limited to those necessary for cooperation with the TMS servicing vehicle. They may include probe, drogue, and locking mechanisms. The weight allocation for these items is 162.3 pounds.

n. Flight Support Equipment (FSE). The FSE hardware category includes all flight vehicle auxiliary equipment necessary to accommodate the payload in the Shuttle Orbiter. This includes any structural support or cradle and all necessary interface equipment required during the launch to LEO, deployment and checkout, etc. This equipment remains with the Orbiter and is not part of the platform vehicle. The weight for this FSE hardware is 2313 pounds and is assumed to be primarily structural in nature. It does not include cradle or deployment equipment associated with the Centaur-F transfer vehicle.

The experimental platform is shown in Figure 3-4 installed in the Shuttle Orbiter together with the Centaur-F which provides LEO to GEO transfer propulsion.

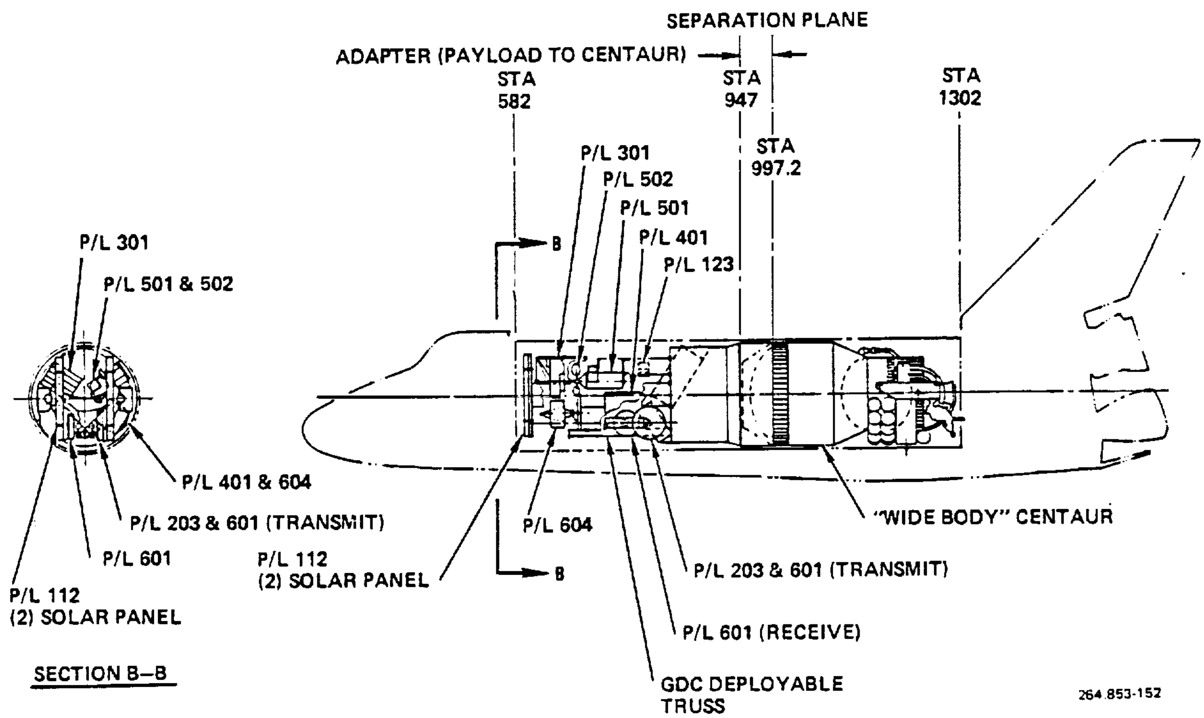

Figure 3-4. Experimental Platform Packaged with the Centaur-F in the Payload Bay

3.2 PROGRAM DEVELOPMENT SCHEDULE

This section summarizes the Experimental Platform development plan schedule generated to support the cost analysis effort. The overall summary milestone schedule and the platform development plan schedule are presented below.

The overall milestone schedule (Figure 3-5) shows a Phase C/D effort for the experimental platform consisting of a 45-month effort starting in 1985 and culminating in the launch of the platform in 1989. The Phase C/D program will be preceded by a Phase B program definition/predesign effort lasting about 12 months in 1983 and into 1984. The current Phase A conceptual studies are envisioned to last through 1982.

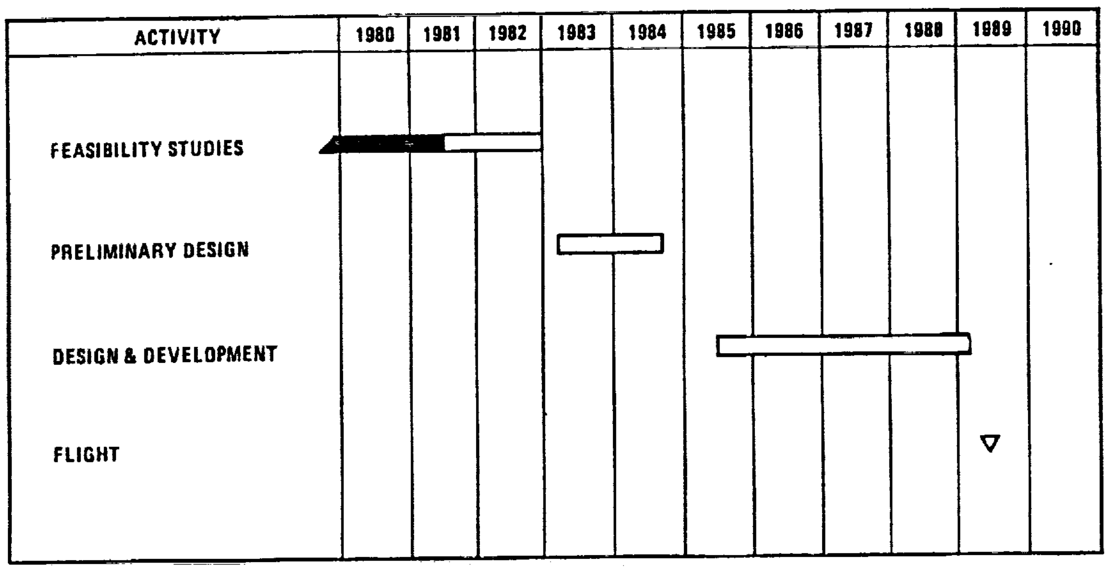

Figure 3-5. Experimental Geostationary Platform Milestone

The Experimental Platform summary development schedule is shown in Figure 3-6. As shown in the milestone schedule, the current Phase A studies are followed by a Phase B Definition Phase study in CY 1983 leading to the Experimental Platform Phase C/D. Continuing supporting research and technology tasks are also planned during this period to support the experimental platform program.

The overall Phase C/D design and development schedule for this platform provides for a 45-month development program leading to the flight of the experimental system in mid-CY 1989. A four-year development period appears reasonably representative for a protoflight program considering the prior Phase B Definition Study activities. This earlier definition and predesign effort is assumed to produce the concept selection and planning data (such as refinement of selected concept and tradeoffs and evaluation of any alternatives), system design data (including preliminary systems specifications), and a complete set of implementation plans (including manufacturing, procurement, test, reliability and safety, quality assurance, configuration management, contract management, data management, operations, etc.). In addition, detailed schedule and resource estimates including funds, manpower, and facilities will be produced. The principal outputs from these "Phase B" type activities are validated requirements, a design solution, and supporting analyses. This information provides a firm foundation for efficiently proceeding with the subsequent Phase C/D activities.

Phase C/D is initiated in mid-CY 1985. Initial design and analysis and development milestones include a Preliminary Requirements Review (PRR) at three months and a Preliminary Design Review (PDR) at five months. The Critical

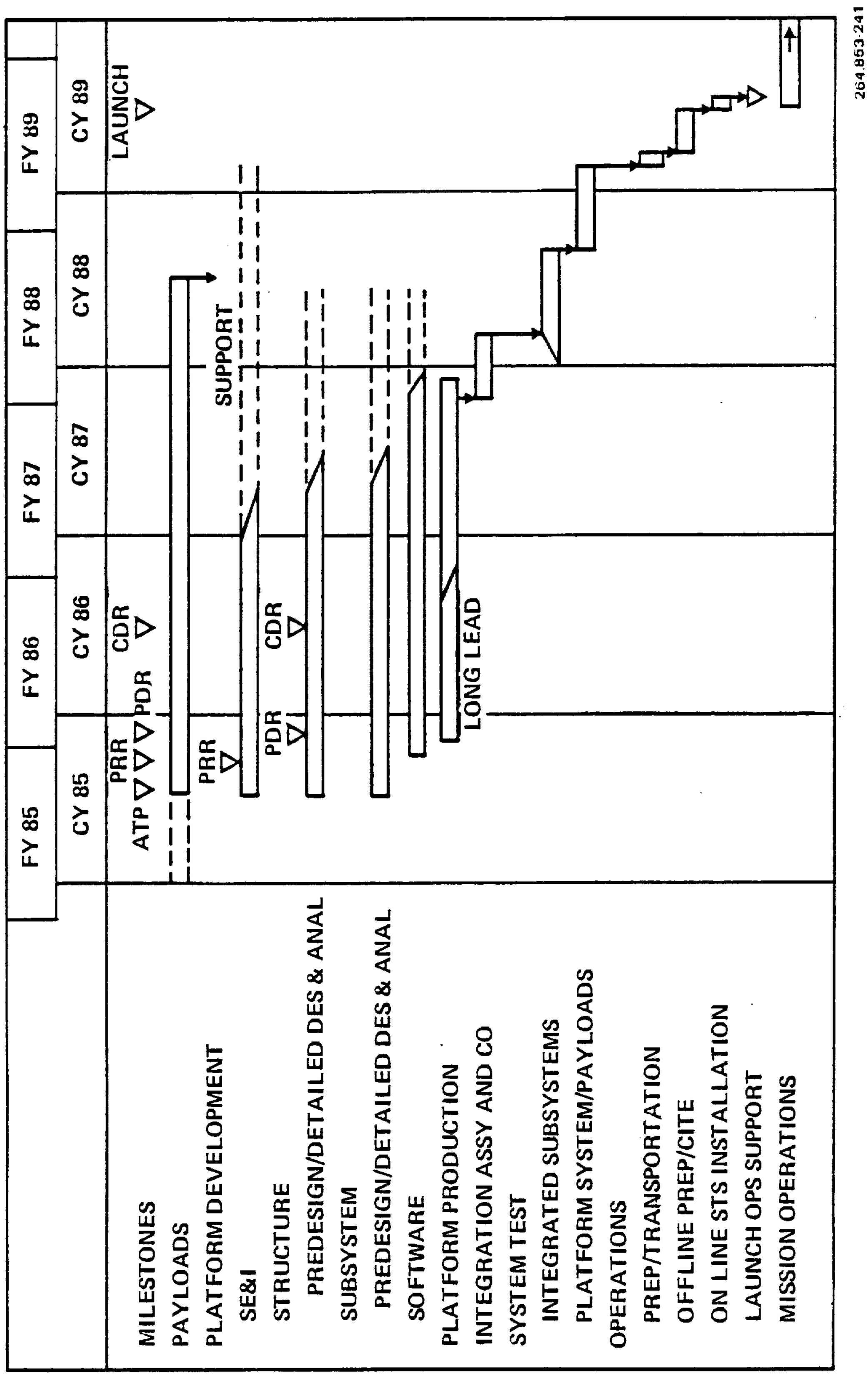

Figure 3-6. Experimental Platform Phase C/D Schedule Summary

Design Review (CDR) follows PDR by 7 months. Structure and subsystem design and analysis and drawing release supports the platform fabrication effort culminating in integration assembly and checkout completion in 33 months. This is followed by a system level test program for the integrated platform subsystems and platform payloads over the following 12 months. Testing of the prototype platform is preceded by component and assembly testing in support of the development effort as well as the required qualification certifications.

As shown, payloads from the concurrent payload development programs are required to support the development platform system testing. The experimental platform then undergoes all-up testing for a period of six months prior to flight. It is then transported to John F. Kennedy Space Center (KSC) for a five-month period for integration processing and installation into the Space Transportation System (STS). This period may be shorter and some of the preparation may be conducted at the contractor plant or a NASA center to minimize STS cargo on-site residency time at KSC. This period is followed by the operational launch, deployment and checkout, transfer to geosynchronous altitude, system activation, and platform operations.

3.3 COST ESTIMATE

This section summarizes the preliminary cost estimate for the Experimental Platform Project described in Section 3.1. The WBS structuring this project is presented in Section 3.4 in the form of a WBS tree and a dictionary defining each cost element. The summary program schedule was presented and discussed in Section 3.2.

3.3.1 METHODOLOGY AND GROUND RULES. Costs for this platform were estimated using the same parametric model employed for the operational system platforms. Certain modifications were made to the cost estimating relationships to accomodate the earlier technology level and the experimental protoflight nature of the project. Because of the very early and brief definition data available for the platform, the costs should be considered provisional and preliminary. As the definition becomes firmer and more detailed in the next phase of study, the estimated costs will become more credible and realistic.

The technology level assumed for this platform is the level predicted for the late 1980s, somewhat earlier than that for the operational platform. Many of the operational system concepts are to be validated on this platform.

The basic objectives of the experimental platform will be to demonstrate the technologies, systems, and operations capabilities necessary to pave the way for operational geostationary platforms of the 1990s, to provide an opportunity to test new communications technologies or services, and to provide an opportunity for science and applications experiments.

The technology level of the platform is driven by efficiency, long life, and reliability (Figure 3-7). Platform efficiency and long life are reflections of

DRIVERS	TECHNOLOGY REQUIREMENTS
OPERATIONAL CONSTRAINTS	
• EFFICIENT OPERATIONS	• HIGH EFFICIENCY SOLAR CELLS • AC POWER DISTRIBUTION
• LONG LIFE	• SOLAR CELLS, STRUCTURAL MATERIALS, BATTERIES, ELECTRIC THRUSTERS FOR STATIONKEEPING
• RELIABILITY	• ON-BOARD REDUNDANCY
• POINTING ACCURACY	• PLATFORM STABILITY AND CONTROL
• MODULAR GROWTH	• RENDEZVOUS SENSING SYSTEMS • DOCKING SENSING SYSTEMS

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Figure 3-7. Platform System, Subsystem, and Component Technology Drivers

the power generation, storage, distribution and management systems, and the components. Reliability is a reflection of component life and redundancy in all system design. To demonstrate these qualities in an experimental platform, the platform should include advanced state-of-the-art in all systems areas. Examples of specific subsystem advanced requirements include:

a. High efficiency silicon or GaAs solar cells (low absorptance, low radiation degradation).

b. High power-density solar array (minimum blanket charge buildup, 16-year survivability).

c. Replenishable nickel hydrogen ($Ni\text{-}H_2$) battery packs (maximized life, adequate thermal interfaces).

d. High frequency high voltage AC power components and interfaces.

e. Microprocessor power management, battery control, power control, array drive and monitors, and associated intradata bus control.

f. Mercury ion and pulsed-plasma (teflon) thrusters for station keeping.

g. Fault-tolerant design and optimized redundancy.

3.3.2 EXPERIMENTAL PLATFORM COST ESTIMATE. Table 3-1 presents the preliminary (ROM) development and flight unit production costs for the experimental platform as defined. These costs were generated parametrically based on preliminary hardware definition and are shown in millions of 1981 constant dollars. It should be noted that cost estimates for the platform life extension service module were not made because of lack of definition at that time. Prime contractor fee and all NASA costs are excluded.

Costs for the subsystem level are shown for the platform itself in terms of the design and development ($105M) and the platform flight hardware fabrication

($46.5M). Rough cost estimates for the payload equipment are also included under WBS 1.5 Payloads and Common User Equipment. Payload costs include payloads 203, 601, and 604 only. Other payloads are issued GFP. The definition of this cost element was not in sufficient detail to permit separation by common user equipment (antennas, etc.) at this time. The integration of this equipment is included with WBS 1.2 System Engineering and Integration, and system level testing is included with WBS 1.9 Integrated Assembly and System Verification. This latter cost element includes all system level test effort, both the platform itself as well as payload integration testing, platform refurbishment, spare parts, and repair parts.

Table 3-1. Preliminary Experimental Platform Project Cost Estimate

WBS	Cost Element	Cost (1981 M$)		
1.0	Experimental Platform Project	431.3		
1.1	Project Management		15.6	
1.2	System Engineering & Integ		27.8	
1.3	Platform Design & Development		105.2	
1.3.1	Structure			26.6
1.3.2	Thermal CTL			12.2
1.3.3	Attitude CTL			29.5
1.3.4	RCS			11.3
1.3.5	EPS			16.2
1.3.6	TT&C			6.3
1.3.7	Rend & Docking			3.1
1.4	Platform Flight Hardware Mfg		38.5	
1.4.1	Structure			5.4
1.4.2	Thermal CTL			3.2
1.4.3	Attitude CTL			4.2
1.4.4	RCS			2.7
1.4.5	EPS			14.5
1.4.6	TT&C			3.7
1.4.7	Rend & Docking			.7
1.4.8	IA&CO			4.1
1.5	Payloads & Common User Equipment		94.0	
1.6	Flight Support Equipment		13.9	
1.7	Ground Support Equipment		18.0	
1.8	Software		8.1	
1.9	Integrated Assy & Sys Verification		38.8	
1.9.1	Test Articles			17.6
1.9.2	Test Ops			16.1
1.9.3	Refurb Spares			5.1
1.10	Launch Operations		69.4	
1.11	Mission Operations		2.0	

Launch operations include the Shuttle and Centaur transportation costs. (As with the Operational GP system, the STS user charge is based on the current guaranteed price for the first three years of operation (18.3M in 1975 $) in lieu of any official follow-on user charge definition. An allowance of $2M for contractor support during mission operations was made. This cost element will be reestimated at a later time when increased definition is available.

As may be seen, the total estimated cost for this project is $431M. This is made up of $269M for the platform itself, $94M for the payloads, and $68.3M for the launch operations including STS user charge.

3.3.3 ANNUAL FUNDING REQUIREMENTS. Phase funding by fiscal year was developed for the experimental platform system by spreading individual cost elements in accordance with the program schedule previously shown. This funding distribution is shown in Figure 3-8. Costs are individually shown for the platform, the communications payloads, and the STS transportation user charge. The overall program funding rises after go-ahead in FY 1985 to a maximum of about $120M/year (excluding STS) in FY 1987, and then declines. The launch is assumed to occur in FY 1989. Sustaining funding for the annual platform operations during the test phase is not included.

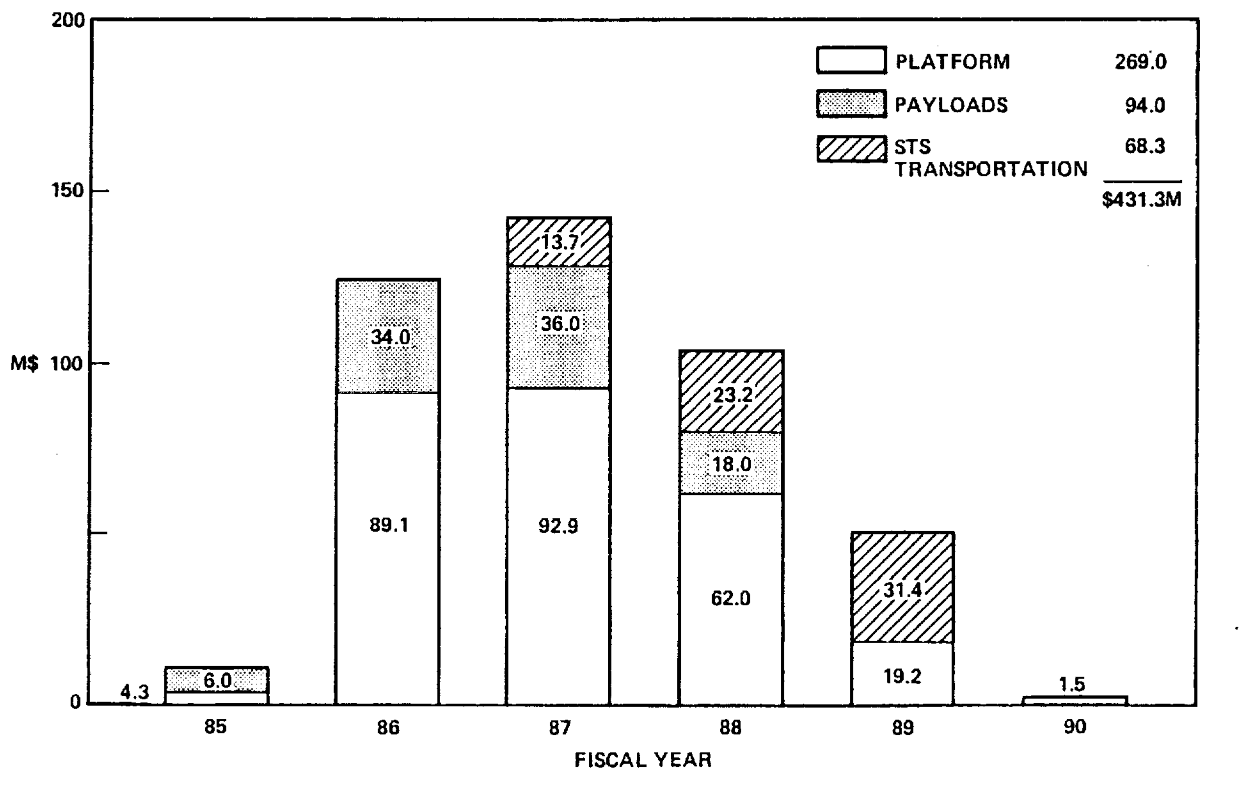

Figure 3-8. Experimental Platform Annual Funding Requirements (1981 $)

3.4 EXPERIMENTAL PLATFORM PROJECT WORK BREAKDOWN STRUCTURE. The WBS for the Experimental Geostationary Platform Project is shown in Figure 3-9. It is a comprehensive breakdown of all total program life-cycle elements categorized or sorted into several levels of hardware and task or function-oriented end items. The WBS serves to identify all of the cost elements to be included in the cost analysis task.

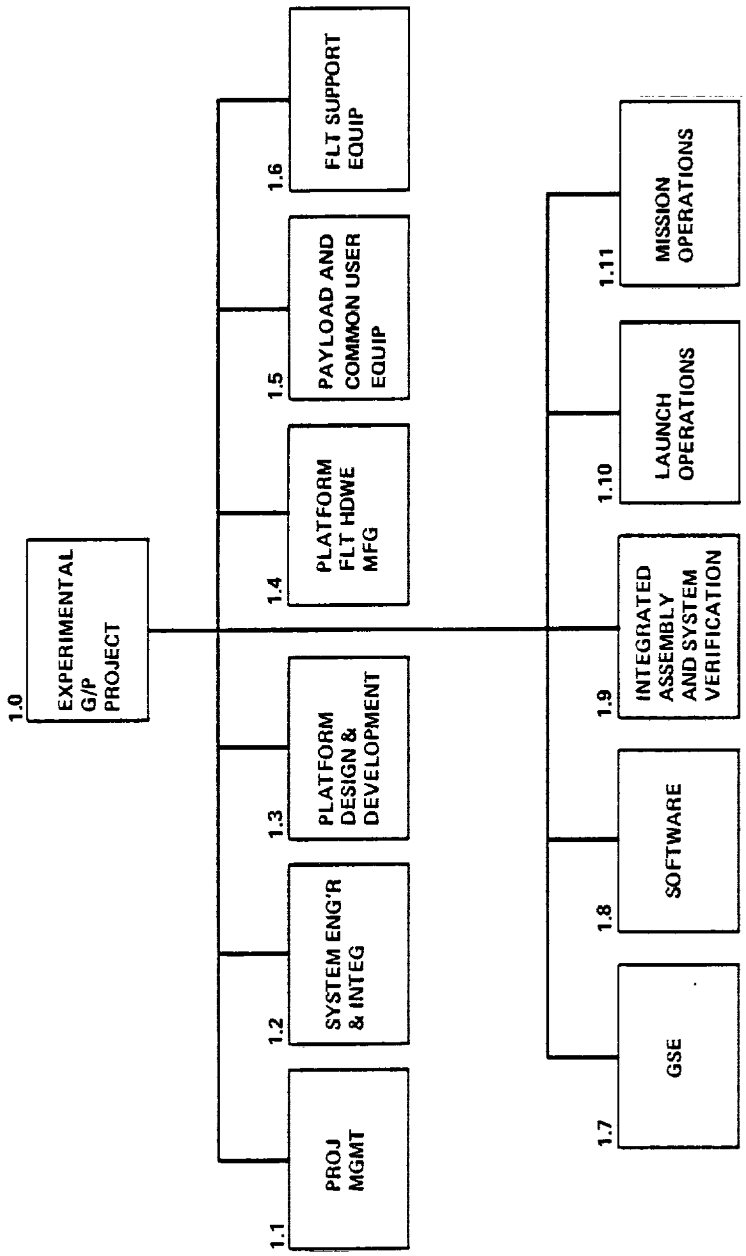

Figure 3-9. Experimental Platform WBS

The following section defines each of the WBS elements for the Experimental Platform. This definition contains applicable inclusions and exclusions and identifies each of the subelements.

WBS No. 1.0 Level 3
WBS Title: Experimental Geostationary Platform Project

This WBS element summarizes all effort and material required for the design, development, fabrication, assembly, test and checkout, and operation of the experimental geostationary platform system.

The following subelements are included:

WBS No.	WBS Title
1.1	Project Management
1.2	Systems Engineering and Integration
1.3	Platform Design and Development
1.4	Platform Flight Hardware Manufacturing
1.5	Common User Equipment
1.6	Flight Support Equipment (FSE)
1.7	Ground Support Equipment (GSE)
1.8	Software
1.9	Integrated Assembly and System Verification
1.10	Launch Operations
1.11	Mission Operations

WBS No. 1.1 Level 4
WBS Title: Project Management

This WBS element summarizes all of the effort required to manage, direct, and control the entire geoplatform project. These functional tasks and activities include planning, organizing, budgeting, scheduling, directing, and controlling other administrative tasks to ensure that the overall objectives of the program are accomplished. The subelements include: Program Direction, Program Planning and Control, Data Management, Procurement Management, and Configuration Management.

WBS No. 1.2 Level 4
WBS Title: System Engineering and Integration

This WBS element summarizes all system level studies, analyses, and tradeoffs to support the development of requirements, specifications, and interfaces necessary to direct and control the design of the overall system. It includes all mission studies and analyses to establish requirements and planning for all phases of the mission and logistics activities. It also includes all product assurance activities consisting of safety, reliability, maintainability, and quality assurance; and parts, material, and processes (PMP) control.

The subelements include: System Analysis and Integration, Mission Requirement Analysis, Logistics Requirements and Analysis, Product Assurance, and Sustaining Engineering during the manufacturing phase.

WBS No. 1.3 Level 4
WBS Title: Platform Design and Development

This WBS element summarizes all effort and material required to design and develop the basic geostationary platform flight vehicle platform module, excluding mission payload equipment.

The vehicle consists of all primary and secondary structure and all supporting subsystems that are necessary for platform functional operation that are needed to provide the necessary mounting space and utility resources to the mission payload equipment.

Platform development includes all requirements analysis and definition, design and analysis, interface integration, subsystem and component hardware fabrication and procurement (for test, and for development and qualification testing thereof), tooling, etc.

The following subsystem subelements are included:

WBS No.	WBS Title
1.3.1	Structure Subsystem
1.3.2	Thermal Control Subsystem
1.3.3	Attitude Control Subsystem
1.3.4	Reaction Control Subsystem
1.3.5	Electrical Power Subsystem
1.3.6	Tracing, Telemetry, and Command Subsystem
1.3.7	Rendezvous and Docking Subsystem

WBS No. 1.3.1.1 Level 6
WBS Title: Primary Structure

This WBS element consists of the primary basic structure making up the platform including core unit, deployable structure members or radial arms, masts, etc. This primary structure provides mounting space and provisions for all supporting subsystems and mission payload equipment.

WBS No. 1.3.1.2 Level 6
WBS Title: Secondary Structure

This WBS element consists of all secondary structure required for the platform. The secondary structure includes mounting bracketry, deployment mechanisms, attachment fittings, etc.

WBS No. 1.3.1.3 Level 6
WBS Title: Tooling

This WBS element consists of all effort and material necessary to provide the required tooling to permit fabrication and assembly of the platform structural elements. It includes design, analysis, drawings, fabrication, assembly, installation, and validation of all tooling items and manufacturing aids.

WBS No. 1.3.2 Level 5
WBS Title: Thermal Control Subsystem

This WBS element consists of all the components and assemblies making up the thermal control subsystem. It may include insulation, louvers, coatings, heat pipes, cold plates, radiators, and other passive thermal control devices. The function of this subsystem is to keep all components within their specified temperature limits.

WBS No. 1.3.3 Level 5
WBS Title: Attitude Control Subsystem (ACS)

This WBS element consists of all of the stabilization and control equipment including all avionics, sensors, and angular momentum control devices (AMCD). The mass expulsion reaction control subsystem (RCS) is excluded from this element and is included as WBS 1.3.4. The primary function of this subsystem is to provide three-axis stabilization of the flight vehicle.

WBS No.	WBS Title
1.3.3.1	ACS Avionics
1.3.3.2	Angular Momentum Control Device (AMCD)

WBS No. 1.3.3.1 Level 6
WBS Title: ACS Avionics

This WBS element consists of all components and assemblies (avionics and related equipment) required for the attitude control subsystem. It may include sun and earth sensors, star trackers, rate gyros, computers, data processors, cabling and harness etc. These components provide attitude sensing, computation, and control signals to the AMCDs and RCS for attitude control and stabilization.

WBS No. 1.3.3.2 Level 6
WBS Title: Angular Momentum Control Devices (AMCD)

This WBS element consists of all angular momentum control devices required for the attitude control subsystem. It may include reaction wheels, single or double gimbal control momentum gyros, controllers, power conditioning, and associated cables and harnesses. These AMCDs provide control forces for attitude control and stabilization.

WBS No. 1.3.4 Level 5
WBS Title: Reaction Control Subsystem

This WBS element consists of all components required for the reaction control subsystem (RCS). It includes thrusters, propellant tanks, propellant feeds, pressurization system, plumbing, valves and sensors, avionics controls, cables and harness, etc. The primary function of this subsystem is to provide control forces by mass expulsion for attitude control and AMCD momentum dumping and potentially for orbit corrections and stationkeeping.

WBS No. 1.3.5 Level 5
WBS Title: Electrical Power Subsystem

This WBS element consists of the solar array system, the battery system, and the power conditioning and distribution system. The primary function of this subsystem is to provide properly conditioned electrical power to all other subsystems and to all required payload and mission equipment carried on the flight vehicle.

The following subelements are included:

WBS No.	WBS Title
1.3.5.1	Solar Array
1.3.5.2	Batteries
1.3.5.3	Power Conditioning and Distribution

WBS No. 1.3.5.1 Level 6
WBS Title: Solar Array

This WBS element consists of the various components making up the solar array including the a) solar panels with their solar cells b) all structure, supporting members, deployment mechanisms, and orientation devices c) electrical buses on the array itself, slip ring assemblies, etc. Its function is to generate raw electrical power and provide to to the power conditioning distribution system for use by platform subsystems and mission payloads, or for storage by means of the batteries.

WBS No. 1.3.5.2 Level 6
WBS Title: Batteries

This WBS element consists of the batteries required for the electrical power subsystems. The function of the batteries is to store electrical power during solar array operation, for use by all systems during solar eclipse periods. .

WBS No. 1.3.5.3 Level 6
WBS Title: Power Conditioning and Distribution

This WBS element consists of all the components and assemblies making up the power conditioning and distribution system including power controllers, battery chargers, inverters, converters, transformers, voltage regulators, current regulators, protection system, and the distribution system - specifically power buses, all electrical cabling and harnesses, and junction/distribution boxes. Its function is to receive raw electrical power from the solar array and to control and provide it to the various subsystem and mission payloads in the proper form (voltage, regulation, etc.).

WBS No. 1.3.6 Level 5
WBS Title: Tracking, Telemetry, and Command Subsystem

The WBS element consists of all the avionics components making up the tracking, telemetry, and command (TT&C) subsystem including all communications, transmitters, receivers, transceivers, antennas, instrumentation and sensors, decoders, multiplexers and other data processors of data formatting, etc., and cabling harnesses. The function of this subsystem is to provide for all ground link housekeeping telemetry and associated onboard instrumentation, remote command and control, and flight vehicle tracking capability. It will also provide for certain mission payloads data handling requirements (data, control, etc.) All user payload communication experiment and operational capability is excluded.

WBS No. 1.3.7 Level 5
WBS Title: Rendezvous and Docking Subsystem

This WBS element consists of all avionics systems and all structural/mechanical systems making up the rendezvous and docking subsystem. The function of this subsystem is to provide for rendezvous and docking of remote servicing vehicles and/or for rendezvous and docking of modular platform flight vehicles themselves.

The following subelements are included:

WBS No.	WBS Title
1.3.7.1	Avionics
1.3.7.2	Structure/Mechanical

WBS No. 1.3.7.1 Level 6
WBS Title: Avionics

This WBS elements consists of all components and assemblies (avionics and related equipment) required for the rendezvous and docking subsystem. It may include microwave transponders, reflectors, or other equipment to cooperate with the TMS.

WBS No. 1.3.7.2 Level 6
WBS Title: Mechanisms

This WBS element consists of all component assemblies necessary to accomplish docking of the TMS and the experimental platform flight vehicle. It may include probe and drogue mechanisms, locking mechanisms, and fluid, electrical, and electronic umbilical connectors.

WBS No. 1.4 Level 4
WBS Title: Platform Flight Hardware Manufacturing

This WBS element summarizes all effort and material required to manufacture the basic geostationary platform flight vehicle platform excluding mission payload equipment.

The vehicle consists of all primary and secondary structure and all supporting subsystems that are necessary for platform functional operation that are needed to provide the necessary mounting space and utility resources to the mission payload equipment.

Platform production includes all fabrication, material, part and components procurement, subassembly, and quality control activities.

The following subelements, defined under WBS element 1.3, are included:

WBS No.	WBS Title
1.4.1	Structure Subsystem
1.4.2	Thermal Control Subsystem
1.4.3	Attitude Control Subsystem
1.4.4	Reaction Control Subsystem
1.4.5	Electrical Power Subsystem
1.4.6	Tracking, Telemetry, and Command Subsystem
1.4.7	Rendezvous and Docking Subsystem
1.4.8	Installation, Assembly and Checkout

WBS No. 1.4.1 through 1.4.7 are defined under WBS 1.3

WBS No. 1.4.8 Level 5
WBS Title: Installation, Assembly and Checkout

This WBS element consists of all effort and materials required to accomplish subsystem installation, final assembly, checkout, and acceptance testing of the platform, and the installation, integration, checkout, and acceptance testing of all mission payloads carried on the platform. These are all ground activities and culminate in selloff to the customer (DD250).

WBS No. 1.5 Level 4
WBS Title: Payload and Common Use Payload Equipment

The WBS element covers all user mission payload equipment provided by the customer. This user equipment can include communications equipment, antennas, transponders, etc., and/or other sensor or experiment equipment. Common use payload equipment covers all specialized communications and/or integration equipment shared by and interfacing with various user payload equipment. This common use equipment can include, but not be limited to, master digital switch and processor (providing payload interconnectivity), communication and data bus and cabling, and equipment mounting and point systems, or multi-user antennas.

WBS No. 1.6 Level 4
WBS Title: Flight Support Equipment (FSE)

This WBS element includes all orbital flight use equipment carried by the Shuttle Orbiter that is not included as part of the platform bus/payload flight vehicle and that is used for deployment or servicing the vehicle. It can include a payload support structure (cradle, etc.) deployment/assembly aids, jigs, and tools; fluid systems such as an abort propellant dump system; controls and displays/caution and warning or other Orbiter aft flight deck equipment; and servicing equipment associated with the remote servicer. This equipment can be required by the platform or by the payloads.

WBS No. 1.7 Level 4
WBS Title: Ground Support Equipment

This WBS element summarizes all effort and material required to define, design, develop, test and qualify, procure, fabricate, assemble, and checkout all new or modified ground support equipment (GSE). It includes all deliverable GSE hardware and its associated software required to support the geostationary platform system during the development, manufacturing, and operations phases, and all effort and material required for GSE maintenance. It includes all necessary handling and transportation equipment, servicing equipment, functional checkout equipment, and maintenance and auxiliary equipment.

WBS No. 1.8 Level 4
WBS Title: Software

This WBS element consists of all labor, material and computer resources necessary to provide validated geostationary platform ground test and flight software. It includes design, programming, validation, and verification. Software for GSE, flight operations, and payloads are excluded from this element and included in those elements.

WBS No. 1.9 Level 4
WBS Title: Integrated Assembly and System Verification

This WBS element summarizes all effort and hardware required to conduct and support all major platform and system level testing necessary to refine and validate the design and verify the accomplishment of the development objectives. They may include but not be limited to full scale structural tests, integrated platform avionics tests, all-up platform functional tests, and payload functional and integration testing. This element includes all major test article fabrication other than the flight vehicle; test article maintenance, refurbishment, and reconfiguration; test planning and test analysis, preparation, test operations, test software, and test support activities.

Excluded are the design and analysis of major test articles, component and subsystem development and qualification testing (WBS 1.3), and fabrication of the flight vehicle (WBS 1.4).

The following subelements are included:

WBS No.	WBS Title
1.9.1	System Test Articles
1.9.2	System Test Operations and Support
1.9.3	Spare and Repair Parts

This program will use the protoflight approach wherein major system level ground testing will be accomplished using the flight vehicle which will then be refurbished for flight.

WBS No. 1.9.1 Level 5
WBS Title: System Test Articles

The WBS element consists of all labor, materials, and services necessary to fabricate major system test articles to be used for system level ground developmental or qualification testing other than flight article manufacturing. It includes all fabrication, material and parts procurement, subassembly, final assembly, and all quality control activities. It also includes all labor and materials necessary to maintain, refurbish, or reconfigure any of the major system ground test articles for reuse in subsequent testing or for flight use.

WBS No. 1.9.2 Level 5
WBS Title: System Test Operations and Support

This WBS element consists of all labor, materials, and services necessary to accomplish the required system test objectives. It includes a) all test planning and design, b) procedures, c) preparation, setup, and setup validation, d) operations, e) teardown and disposition, f) data recovery, analysis, and evaluation, and g) final documentation. It also includes test software and all test supporting activities.

WBS No. 1.9.3 Level 5
WBS Title: Spare and Repair Parts

This WBS element consists of the procurement of all required spare and repair parts consumed during the ground operations phase as well as for the refurbishment of the platform to flight configuration.

WBS No. 1.10 Level 4
WBS Title: Launch Operations

This WBS element consists of all effort and material required for the ground operations and integration phase prior to launch, launch, and post mission tasks. It begins with NASA acceptance of the vehicle (DD250) and ends with the Shuttle return and demating operations. It includes transportation to the integration and/or launch site, all integration preparations, chargeable costs for installation and integration into the Shuttle Orbiter, launch operations support and post mission operations. (Costs for tasks under STS standard ground operations are included in the basic STS user charge.)

WBS No. 1.11 Level 4
WBS Title: Mission Operations

This WBS element consists of all effort and materials required to support on-orbit flight test operations during placement, on-orbit deployment and/or assembly, test and checkout, transfer to geosynchronous orbit and checkout, and activation of the platform and conduct of the required testing.

It includes Payloads Control Center Operations (POCC), and unique communications and data activities. It also includes the mission and/or payload specialists (flight crew) and the geostationary platform system-unique training but excludes the space flight training (WBS 1.17) and STS optional services such as EVA (WBS 1.15) required for the placement flight.

It also includes all contractor effort and materials required (not provided during the mission testing phase) for sustaining engineering and planning support. Also included is engineering support in problem simulation and resolution during the platform test operations.

APPENDIX A

DETAILED COST ESTIMATES

Table A-1. RIA Alternative 1

G/P Platform Preliminary Cost Estimate (1981 M$)

Platform Module No. 1

COST ELEMENT	SIZE PARAMETER	COMMONALITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	1811.2	1.00	17.24	4.25
STRUCTURE (SEC)	95.3	1.00	4.15	.46
TOOLING		1.00	1.99	
THERMAL CTL	423.4	1.00	13.28	2.99
ACS AVIONICS	106.5	1.00	35.12	3.68
ACS AMCD	70.0	1.00	5.45	2.26
RCS	365.1	1.00	14.80	2.75
EPS SOLAR ARRAY	10.4	1.00	13.62	14.50
EPS BATTERIES	2.6	1.00	4.03	1.24
EPS COND & DIST	538.9	1.00	12.28	3.68
TT&C	106.5	1.00	7.35	3.03
R&D AVIONICS	15.2	1.00	1.20	.23
R&D MECH	68.5	1.00	2.89	.29
FLIGHT SOFTWARE	50000.0	1.00	12.50	
SUBTOTAL			145.90	39.34
IA&CO				4.72
SUSTAIN ENG				3.30
SE&I		1.00	25.53	
SYSTEM TEST				
TEST ART		1.00	56.97	
TEST OPS		1.00	14.12	
GSE		1.00	29.18	
GND SOFTWARE	20000.0	1.00	1.26	
FSE	1500.0	1.00	22.13	
FACILITIES & STE		1.00	15.64	
SPARES		1.00	11.80	
PROGRAM MGMT			16.13	2.37
TOTAL			338.65	49.73

Table A-2. RIA Alternative 1

G/P System Level Cost Summary (1981 M$)

Platform Module No. 1

Cost Element	Development Cost	Unit Cost
Platform	338.65	49.73
Payloads		
No. 3 TV Distribution	35.72	21.60
No. 27 RF Interferometer	14.61	3.84
No. 52 Boss Eval	21.53	3.34
No. 11 IPL (2 required)	22.43	21.60
Master Switch	14.41	5.98
Interservice Switch	6.44	2.20
Payload Total	115.14	58.56
System Level Costs		
IA&CO (3% PLU)	---	1.76
SE&I (5.8% PLD)	6.68	---
System Test		
Test Article (10% PLU)	5.86	---
Test Ops (6.2% PLU)	3.63	---
Program Mgmt Dev 2% PLD	2.30	---
5% SYS	0.81	---
Unit 1% PLU	---	0.59
5% SYS	---	0.09
System Total	19.28	2.44
PROGRAM TOTAL	473.07	110.73

Table A-3. RIA Alternative 1

G/P Platform Preliminary Cost Estimate (1981 M$)

Platform Module No. 2

COST ELEMENT	SIZE PARAMETER	COMMONALITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	2637.4	.22	4.58	5.45
STRUCTURE (SEC)	138.8	.67	3.35	.59
TOOLING		.22	.60	
THERMAL CTL	560.3	.50	7.10	3.60
ACS AVIONICS	106.5	.10	3.51	3.68
ACS AMCD	70.0	.00		2.26
RCS	425.9	.20	3.04	3.11
EPS SOLAR ARRAY	14.0	.10	1.65	18.59
EPS BATTERIES	2.6	.00		1.85
EPS COND & DIST	638.9	.15	1.84	3.68
TT&C	106.5	.00		3.03
R&D AVIONICS	15.2	.00		.23
R&D MECH	63.5	.00		.29
FLIGHT SOFTWARE	50000.0	.15	1.88	
SUBTOTAL			27.55	46.35
IA&CO				5.56
SUSTAIN ENG				3.89
SE&I		1.00	4.82	
SYSTEM TEST				
TEST ART		.20	12.98	
TEST OPS		.50	8.04	
GSE		.10	.55	
GND SOFTWARE	20000.0	.15	.19	
FSE	1500.0	.02	.44	
FACILITIES & STE		.00		
SPARES		.30	4.17	
PROGRAM MGMT			2.94	2.79
TOTAL			61.68	58.60

Table A-4. RIA Alternative 1

G/P System Level Cost Summary (1981 M$)

Platform Module No. 2

Cost Element		Development Cost	Unit Cost
Platform		61.68	58.60
Payloads			
1.1 KuVE		31.98	18.64
1.1 KuHE		5.55	8.97
1.1 KuHW		10.08	19.92
1.1 KuVW		4.70	7.19
1.3 KaHE		47.83	29.65
1.2 KaVE		12.49	24.65
11 IPL (2 required)		---	21.60
Payload Total		112.63	130.62
System Level Costs			
IA&CO (3% PLU)		---	3.92
SE&I (5.8% PLD)		6.53	---
System Test			
Test Article (10% PLU)		13.06	---
Test Ops (6.2% PLU)		8.10	---
Program Mgmt Dev	2% PLD	2.25	---
	5% SYS	1.38	---
Unit	1% PLU	---	1.31
	5% SYS	---	0.20
System Total		31.32	5.43
PROGRAM TOTAL		205.63	194.65

Table A-5. RIA Alternative 1

G/P Platform Preliminary Cost Estimate (1981 (M$)

Platform Module No. 3

COST ELEMENT	SIZE PARAMETER	COMMONALITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	2485.6	.07	1.41	5.24
STRUCTURE (SEC)	130.8	.67	3.26	.56
TOOLING		.07	.18	
THERMAL CTL	413.0	.25	3.30	2.94
ACS AVIONICS	106.5	.05	1.76	3.68
ACS AMCD	70.0	.00		2.26
RCS	403.1	.10	1.51	2.98
EPS SOLAR ARRAY	10.6	.00		14.72
EPS BATTERIES	2.6	.00		1.24
EPS COND & DIST	638.9	.10	1.23	3.68
TT&C	106.5	.00		3.03
R&D AVIONICS	15.2	.00		.23
R&D MECH	68.5	.00		.29
FLIGHT SOFTWARE	50000.0	.10	1.25	
SUBTOTAL			13.89	40.83
IA&CO		.00		4.90
SUSTAIN ENG		.00		3.43
SE&I		1.00	2.43	
SYSTEM TEST		.00		
TEST ART		.15	8.95	
TEST OPS		.50	7.39	
GSE		.10	.28	
GND SOFTWARE	20000.0	.15	.19	
FSE	1500.0	.02	.44	
FACILITIES & STE		.00		
SPARES		.10	1.22	
PROGRAM MGMT		.00	1.74	2.46
TOTAL			36.53	51.62

Table A-6. RIA Alternative 1

G/P System Level Cost Summary (1981 M$)

Platform Module No. 3

Cost Element	Development Cost	Unit Cost
Platform	36.53	51.62
Payloads		
1.1 KuVM	2.40	9.99
1.3 KuHP	7.87	14.32
1.3 KuVB	7.97	14.56
1.3 KuHA	7.77	14.08
1.2 KaVW	13.64	27.72
7 Airmobile	31.72	17.15
11 IPL (2 required)	---	21.60
Payload Total	71.37	119.42
System Level Costs		
IA&CO (3% PLU)	---	3.58
SE&I (5.8% PLD)	4.14	---
System Test		
Test Article (10% PLU)	11.94	---
Test Ops (6.2% PLU)	7.40	---
Program Mgmt Dev 2% PLD	1.43	---
5% SYS	1.17	---
Unit 1% PLU	---	1.19
5% SYS	---	0.18
System Total	26.08	4.95
PROGRAM TOTAL	133.98	175.99

Table A-7. RIA Alternative 1

G/P Platform Preliminary Cost Estimate (1981 M$)

Platform Module No. 4

COST ELEMENT	SIZE PARAMETER	COMMONALITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	2543.4	.21	4.29	5.32
STRUCTURE (SEC)	133.3	.67	3.29	.57
TOOLING		.21	.56	
THERMAL CTL	180.0	.30	5.25	1.69
ACS AVIONICS	106.5	.05	1.76	3.68
ACS AMCD	70.0	.00		2.26
RCS	382.8	.15	2.24	2.85
EPS SOLAR ARRAY	4.4	.10	.78	7.00
EPS BATTERIES	2.6	.00		.62
EPS CCND & DIST	479.2	.15	1.46	2.83
TT&C	106.5	.00		3.03
R&D AVIONICS	15.2	.00		.23
R&D MECH	68.5	.00		.29
FLIGHT SOFTWARE	50000.0	.10	1.25	
SUBTOTAL			18.88	30.36
IA&CO		.00		3.64
SUSTAIN ENG		.00		2.55
SE&I		1.00	3.30	
SYSTEM TEST		.00		
TEST ART		.10	5.03	
TEST OPS		.30	3.74	
GSE		.05	.19	
GND SOFTWARE	20000.0	.10	.13	
FSE	1500.0	.02	.44	
FACILITIES & STE		.00		
SPARES		.10	.91	
PROGRAM MGMT		.00	1.63	1.83
TOTAL			34.24	38.38

Table A-8. RIA Alternative 1

G/P System Level Cost Summary (1981 M$)

Platform Module No. 4

Cost Element	Development Cost	Unit Cost
Platform	34.24	38.38
Payloads		
1.3 CTG/CRG	44.74	29.17
12 Data Collection	22.43	10.80
19 Visual and IR Radiometer	39.33	9.32
31 DMSP Data Relay	18.62	5.31
11 IPL (2 required)	---	21.60
Payload Total	125.12	76.20
System Level Costs		
IA&CO (3% PLU)	---	2.29
SE&I (5.8% PLD)	7.26	---
System Test		
Test Article (10% PLU)	7.62	---
Test Ops (6.2% PLU)	4.72	---
Prog Mgmt Dev 2% PLD	2.50	---
5% SYS	0.74	---
Unit 1% PLU	---	0.76
5% SYS	---	0.11
System Total	22.84	3.16
PROGRAM TOTAL	182.20	117.74

Table A-9. RIA Alternative 1

G/P System Level Cost Summary (1981 M$)

Platform Module No. 5

COST ELEMENT	SIZE PARAMETER	COMMONALITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	2591.6	.22	4.54	5.39
STRUCTURE (SEC)	136.4	.67	3.33	.58
TOOLING		.22	.59	
THERMAL CTL	550.2	.30	4.24	3.56
ACS AVIONICS	106.5	.05	1.76	3.68
ACS AMCD	70.0	.00		2.26
RCS	395.5	.15	2.25	2.93
EPS SOLAR ARRAY	13.5	.00		18.07
EPS BATTERIES	2.6	.00		1.55
EPS COND & DIST	638.9	.10	1.23	3.68
TT&C	106.5	.00		3.03
R&D AVIONICS	15.2	.00		.23
R&D MECH	68.5	.00		.29
FLIGHT SOFTWARE	50000.0	.10	1.25	
SUBTOTAL			19.18	45.23
IA&CO		.00		5.43
SUSTAIN ENG		.00		3.80
SE&I		1.00	3.36	
SYSTEM TEST		.00		
TEST ART		.10	6.34	
TEST OPS		.30	4.71	
GSE		.05	.19	
GND SOFTWARE	20000.0	.10	.13	
FSE	1500.0	.01	.22	
FACILITIES & STE		.00		
SPARES		.10	1.36	
PROGRAM MGMT		.00	1.77	2.72
TOTAL			37.27	57.18

Table A-10. RIA Alternative 1

G/P System Level Cost Summary (1981 M$)

Platform Module No. 5

Cost Element	Development Cost	Unit Cost
Platform	37.27	57.18
Payloads		
6 Direct to Home TV	35.72	21.60
9 Land Mobile	51.30	26.00
33 Materials Exposure	1.06	0.18
43 Magnetic Substorm Monitor	4.21	0.73
56 Fibre Optics Demo	1.06	0.18
11 IPL (2 required)	---	21.60
Payload Total	93.35	70.29
System Level Costs		
IA&CO (3% PLU)	---	2.11
SE&I (5.8% PLD)	5.41	---
System Test		
Test Article (10% PLU)	7.03	---
Test Ops (6.2% PLU)	4.36	---
Prog Mgmt Dev 2% PLD	1.87	---
5% SYS	0.84	---
Unit 1% PLU	---	0.70
5% SYS	---	0.11
System Total	19.51	2.92
PROGRAM TOTAL	150.13	130.39

Table A-11. RIA Alternative 1

G/P Platform Preliminary Cost Estimate (1981 M$)

Platform Module No. 6

COST ELEMENT	SIZE PARAMETER	COMMONALITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	1953.3	.10	1.79	4.46
STRUCTURE (SEC)	102.8	.67	2.89	.48
TOOLING		.10	.21	
THERMAL CTL	81.1	.30	2.68	.99
ACS AVIONICS	106.5	.02	.70	3.68
ACS AMCD	70.0	.00		2.26
RCS	339.7	.10	1.46	2.59
EPS SOLAR ARRAY	2.0	.05	.23	3.56
EPS BATTERIES	2.6	.00		.31
EPS COND & DIST	479.2	.10	.98	2.83
TT&C	106.5	.00		3.03
R&D AVIONICS	15.2	.00		.23
R&D MECH	68.5	.00		.29
FLIGHT SOFTWARE	50000.0	.05	.63	
SUBTOTAL			11.57	24.70
IA&CO		.00		2.96
SUSTAIN ENG		.00		2.07
SE&I		1.00	2.02	
SYSTEM TEST		.00		
TEST ART		.10	4.41	
TEST OPS		.20	2.19	
GSE		.05	.12	
GND SOFTWARE	20000.0	.05	.06	
FSF	1500.0	.01	.22	
FACILITIES & STE		.00		
SPARES		.10	.74	
PROGRAM MGMT		.00	1.07	1.49
TOTAL			22.39	31.23

Table A-12. RIA Alternative 1

G/P System Level Cost Summary (1981 M$)

Platform Module No. 6

Cost Element	Development Cost	Unit Cost
Platform	22.39	31.23
Payloads		
5 Educational TV	39.19	24.45
11 IPL (2 required)	---	21.60
Master Switch	---	5.98
Interservice Switch	---	2.20
Payload Total	39.19	54.23
System Level Costs		
IA&CO (3% PLU)	---	1.63
SE&I (5.8% PLD)	2.27	---
System Test		
Test Article (10% PLU)	5.42	---
Test Ops (6.2% PLU)	3.36	---
Prog Mgmt Dev 2% PLD	0.78	---
5% SYS	0.55	---
Unit 1% PLU	---	0.54
5% SYS	---	0.08
System Total	12.38	2.25
PROGRAM TOTAL	73.96	87.71

Table A-13. RIA Alternative 1

G/P Platform Preliminary Cost Estimate (1981 M$)

Platform Module No. 7

COST ELEMENT	SIZE PARAMETER	COMMONALITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	1926.8	.03	.53	4.42
STRUCTURE (SEC)	101.4	.67	2.87	.47
TOOLING		.03	.06	
THERMAL CTL	235.8	.25	2.89	2.02
ACS AVIONICS	106.5	.02	.70	3.68
ACS AMCD	70.0	.00		2.26
RCS	377.8	.05	.74	2.82
EPS SOLAR ARRAY	5.8	.05	.46	8.80
EPS BATTERIES	2.6	.00		.62
EPS COND & DIST	479.2	.10	.98	2.83
TT&C	106.5	.00		3.03
R&D AVIONICS	15.2	.00		.23
R&D MECH	68.5	.00		.29
FLIGHT SOFTWARE	50000.0	.05	.63	
SUBTOTAL			9.86	31.47
IA&CO		.00		3.78
SUSTAIN ENG		.00		2.64
SE&I		1.00	1.73	
SYSTEM TEST		.00		
TEST ART		.05	2.49	
TEST OPS		.20	2.47	
GSE		.05	.10	
GND SOFTWARE	20000.0	.05	.06	
FSE	1500.0	.01	.22	
FACILITIES & STE		.00		
SPARES		.00		
PROGRAM MGMT		.00	.85	1.89
TOTAL			17.77	39.78

Table A-14. RIA Alternative 1

G/P System Level Cost Summary (1981 M$)

Platform Module No. 7

Cost Element	Development Cost	Unit Cost
Platform	17.77	39.78
Payloads		
4 Tracking & Data Relay	40.56	23.80
17 Lightning Mapper	27.65	6.92
32 OLS Cloud Imager	21.53	3.34
38 Cloud Height Sensor	12.43	1.31
42 Global UV Radiance	10.93	1.74
54 DoD EHF Exp	20.22	5.93
55 DoD Laser Comm Exp	27.65	6.92
11 IPL (2 required)	---	21.60
Payload Total	160.97	71.56
System Level Costs		
IA&CO (3% PLU)	---	2.15
SE&I (5.8% PLD	9.34	---
System Test		
Test Article (10% PLU)	7.16	---
Test Ops (6.2% PLU)	4.44	---
Prog Mgmt Dev 2% PLD	3.22	---
5% SYS	1.05	---
Unit 1% PLU	---	0.72
5% SYS	---	0.11
System Total	25.21	2.98
PROGRAM TOTAL	203.95	114.32

Table A-15. RIA Alternative 1

G/P Platform Preliminary Cost Estimate (1981 M$)

Platform Module No. 8

COST ELEMENT	SIZE PARAMETER	COMMONALITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	1801.6	.03	.52	4.23
STRUCTURE (SEC)	94.8	.67	2.77	.45
TOOLING		.03	.06	
THERMAL CTL	228.2	.25	2.86	1.98
ACS AVIONICS	106.5	.02	.70	3.68
ACS AMCD	70.0	.00		2.26
RCS	370.2	.05	.74	2.78
EPS SOLAR ARRAY	5.6	.00		8.54
EPS BATTERIES	2.6	.00		.62
EPS COND & DIST	479.2	.10	.98	2.83
TT&C	106.5	.00		3.03
R&D AVIONICS	15.2	.00		.23
R&D MECH	68.5	.00		.29
FLIGHT SOFTWARE	50000.0	.05	.63	
SUBTOTAL			9.25	30.90
IA&CO		.00		3.71
SUSTAIN ENG		.00		2.60
SE&I		1.00	1.62	
SYSTEM TEST		.00		
TEST ART		.05	2.45	
TEST OPS		.20	2.43	
GSF		.05	.09	
GND SOFTWARE	20000.0	.05	.06	
FSF	1500.0	.01	.22	
FACILITIES & STE		.00		
SPARES		.00		
PROGRAM MGMT		.00	.81	1.86
TOTAL			16.94	39.07

Table A-16. RIA Alternative 1

G/P System Level Cost Summary (1981 M$)

Platform Module No. 8

Cost Element	Development Cost	Unit Cost
Platform	16.94	39.07
Payloads		
18 Atmos Sounder	21.02	4.59
20 Microwave Radio	15.55	4.17
71 Earth Optical Telescope	58.31	18.22
11 IPL (2 required)	---	21.60
Payload Total	94.88	48.58
System Level Costs		
IA&CO (3% PLU)	---	1.46
SE&I (5.8% PLD	5.50	---
System Test		
Test Article (10% PLU)	4.86	---
Test Ops (6.2% PLU)	3.01	---
Prog Mgmt Dev 2% PLD	1.90	---
5% SYS	0.67	---
Unit 1% PLU	---	0.49
5% SYS	---	0.07
System Total	15.94	2.02
PROGRAM TOTAL	127.76	89.67

Table A-17. RIA Alternative 2

G/P Platform Preliminary Cost Estimate (1981 M$)

Platform Module No. 1

COST ELEMENT	SIZE PARAMETER	COMMONALITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	2721.7	1.00	21.13	5.57
STRUCTURE (SEC)	143.2	1.00	5.09	.60
TOOLING		1.00	2.82	
THERMAL CTL	1168.9	1.00	16.95	5.88
ACS AVIONICS	106.5	1.00	35.12	3.68
ACS AMCD	500.0	1.00	8.08	2.80
RCS	413.3	1.00	15.13	3.04
EPS SOLAR ARRAY	28.8	1.00	26.34	34.36
EPS BATTERIES	2.6	1.00	4.03	3.71
EPS COND & DIST	1277.8	1.00	21.36	6.97
TT&C	106.5	1.00	7.35	3.03
R&D AVIONICS	100.0	1.00	30.17	1.31
R&D MECH	137.0	1.00	4.09	.45
FLIGHT SOFTWARE	60000.0	1.00	15.00	
SUBTOTAL			212.66	71.40
IA&CO		.00		8.57
SUSTAIN ENG		.00		6.00
SE&I		1.00	37.22	
SYSTEM TEST		.00		
TEST ART		1.00	91.35	
TEST OPS		1.00	22.63	
GSE		1.00	42.53	
GND SOFTWARE	30000.0	1.00	1.89	
FSE	1500.0	1.00	22.13	
FACILITIES & STE		1.00	21.61	
SPARES		1.00	21.42	
PROGRAM MGMT		.00	23.67	4.30
TOTAL			497.10	90.26

Table A-18. RIA Alternative 2

G/P System Level Cost Summary (1981 (M$)

Platform Module No. 1

Cost Element	Development Cost	Unit Cost
Platform	497.10	90.26
Payloads		
3	35.72	21.60
11 (1 required)*		
Master Switch	14.41	5.98
Interservice Switch	6.44	2.20
Payload Total	56.57	29.78
System Level Costs		
IA&CO	---	0.89
SE&I	3.28	---
System Test		
Test Article	2.98	---
Test Ops	1.85	---
Program Mgmt Dev	1.54	0.34
System Total	9.65	1.23
PROGRAM TOTAL	563.32	121.27

*IPL for Comm with Atlantic Platform deleted for consistency with RIA/ALT1 and AA-2/ALT2.

Table A-19. RIA Alternative 2

G/P Platform Preliminary Cost Estimate (1981 M$)

Platform Module No. 2

COST ELEMENT	SIZE PARAMETER	COMMONALITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	2398.9	.35	6.84	5.12
STRUCTURE (SEC)	126.3	.67	3.20	.55
TOOLING		.35	.87	
THERMAL CTL	50.0	.20	1.59	.72
ACS AVIONICS	106.5	.05	1.76	3.68
ACS AMCD		.00		
RCS	377.8	.30	4.47	2.82
EPS SOLAR ARRAY		.00		
EPS BATTERIES	2.6	.00		.31
EPS COND & DIST	100.0	.50	1.39	.67
TT&C	12.7	.00		.56
R&D AVIONICS	12.7	.10	2.24	.19
R&D MECH	34.3	.10	.20	.18
FLIGHT SOFTWARE	30000.0	.30	2.25	
SUBTOTAL			24.82	14.81
IA&CO		.00		1.78
SUSTAIN ENG		.00		1.24
SE&I		1.00	4.34	
SYSTEM TEST		.00		
TEST ART		.20	5.93	
TEST OPS		.50	3.67	
GSE		.10	.50	
GND SOFTWARE	30000.0	.15	.29	
FSE	1500.0	.02	.44	
FACILITIES & STE		.00		
SPARES		.30	1.33	
PROGRAM MGMT		.00	2.07	.89
TOTAL			43.38	18.72

Table A-20. RIA Alternative 2

G/P System Level Cost (1981 M$)

Platform Module No. 2

Cost Element	Development Cost	Unit Cost
Platform	43.38	18.72
Payloads		
1.1 KuVE	31.98	18.64
1.1 KuHE	5.55	8.97
1.1 KuHW	10.08	19.92
1.1 KuVW	4.70	7.19
1.3 KaHE	47.83	29.65
1.2 KaVW	13.64	27.72
32	21.53	3.34
38	12.43	1.31
52	21.53	3.34
Payload Total	169.27	120.08
System Level Costs		
IA&CO	---	3.60
SE&I	9.82	---
System Test		
Test Article	12.01	---
Test Ops	7.44	---
Program Mgmt Dev	4.85	1.38
System Total	34.12	4.98
PROGRAM TOTAL	246.77	143.78

Table A-21. RIA Alternative 2

G/P Platform Preliminary Cost Estimate (1981 M$)

Platform Module No. 3

COST ELEMENT	SIZE PARAMETER	COMMONALITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	2126.8	.30	5.51	4.73
STRUCTURE (SEC)	111.9	.67	3.01	.51
TOOLING		.30	.67	
THERMAL CTL	50.0	.20	1.59	.72
ACS AVIONICS	106.5	.03	.70	3.68
ACS AMCD		.00		
RCS	342.3	.05	.73	2.61
EPS SOLAR ARRAY		.00		
EPS BATTERIES	2.6	.00		.31
EPS COND & DIST	100.0	.00		.67
TT&C	12.7	.03		.56
R&D AVIONICS	12.7	.00		.19
R&D MECH	34.3	.09		.18
FLIGHT SOFTWARE	30000.0	.05	.38	
SUBTOTAL			12.59	14.15
IA&CO		.00		1.70
SUSTAIN ENG		.00		1.19
SE&I		1.00	2.20	
SYSTEM TEST		.00		
TEST ART		.05	1.42	
TEST OPS		.30	2.11	
GSE		.05	.13	
GND SOFTWARE	30000.0	.05	.09	
FSE	1500.0	.01	.22	
FACILITIES & STE		.00		
SPARES		.10	.42	
PROGRAM MGMT		.00	.96	.85
TOTAL			20.15	17.89

Table A-22. RIA Alternative 2

G/P System Level Cost Summary (1981 M$)

Platform Module No. 3

Cost Element	Development Cost	Unit Cost
Platform	20.15	17.89
Payloads		
1.1 KuVM	2.40	9.99
1.3 KuHP	7.87	14.32
1.3 KuVB	7.97	14.56
1.3 KuHA	7.77	14.08
5	39.19	24.45
54	20.22	5.93
56	1.06	0.18
Payload Total	86.48	83.51
System Level Costs		
IA&CO	---	2.51
SE&I	5.02	---
System Test		
Test Article	8.35	---
Test Ops	5.18	---
Program Mgmt Dev	2.66	0.97
System Total	21.21	3.48
PROGRAM TOTAL	127.84	104.88

Table A-23. RIA Alternative 2

G/P Platform Preliminary Cost Estimate (1981 M$)

Platform Module No. 4

COST ELEMENT	SIZE PARAMETER	COMMONALITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	2601.2	.19	3.76	5.40
STRUCTURE (SEC)	136.3	.67	3.33	.58
TOOLING		.18	.49	
THERMAL CTL	50.0	.20	1.59	.72
ACS AVIONICS	106.5	.02	.70	3.68
ACS AMCD		.00		
RCS	352.4	.05	.74	2.67
EPS SOLAR ARRAY		.00		
EPS BATTERIES	2.6	.00		.31
EPS COND & DIST	100.0	.00		.67
TT&C	12.7	.00		.56
R&D AVIONICS	12.7	.00		.19
R&D MECH	34.3	.02		.19
FLIGHT SOFTWARE	30000.0	.05	.38	
SUBTOTAL			10.99	14.37
IA&CO		.00		1.90
SUSTAIN ENG		.00		1.26
SE&I		1.00	1.92	
SYSTEM TEST		.00		
TEST ART		.05	1.50	
TEST OPS		.20	1.48	
GSE		.05	.11	
GND SOFTWARE	30000.0	.05	.09	
FSE	1500.0	.01	.23	
FACILITIES & STE		.00		
SPARES		.10	.45	
PROGRAM MGMT		.00	.84	.90
TOTAL			17.61	18.92

Table A-24. RIA Alternative 2

G/P System Level Cost Summary (1981 M$)

Platform Module No. 4

Cost Element	Development Cost	Unit Cost
Platform	17.61	18.92
Payloads		
1.2 KaVE	12.49	24.65
1.3 CTG/CRG	44.74	29.17
12	22.43	10.80
17	27.65	6.92
18	21.01	4.59
19	39.33	9.32
20	15.55	4.17
31	18.62	5.31
33	1.06	0.18
43	4.21	0.73
Payload Total	207.10	95.84
System Level Costs		
IA&CO	---	2.88
SE&I	12.01	---
System Test		
Test Article	9.58	---
Test Ops	5.94	---
Program Mgmt Dev	5.52	1.10
System Total	33.05	3.98
PROGRAM TOTAL	257.76	118.74

Table A-25. RIA Alternative 2

G/P Platform Preliminary Cost Estimate (1981 M$)

Platform Module No. 5

COST ELEMENT	SIZE PARAMETER	COMMONALITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	1820.9	.24	4.11	4.26
STRUCTURE (SEC)	95.8	.67	2.79	.46
TOOLING		.24	.48	
THERMAL CTL	1158.6	.30	5.07	5.85
ACS AVIONICS	106.5	.05	1.76	3.68
ACS AMCD	500.0	.00		2.80
RCS	408.2	.10	1.51	3.01
EPS SOLAR ARRAY	28.6	.03	.79	34.16
EPS BATTERIES	2.6	.00		3.40
EPS COND & DIST	1277.5	.10	2.14	6.97
TT&C	106.5	.00		3.03
R&D AVIONICS	100.0	.00		1.31
R&D MECH	137.0	.00		.45
FLIGHT SOFTWARE	60000.0	.10	1.50	
SUBTOTAL			20.14	69.37
IA&CO		.00		8.32
SUSTAIN ENG		.00		5.83
SE&I		1.00	3.52	
SYSTEM TEST		.00		
TEST ART		.10	8.76	
TEST OPS		.30	6.51	
GSE		.10	.40	
GND SOFTWARE	30000.0	.10	.19	
FSE	1500.0	.01	.22	
FACILITIES & STE		.00		
SPARES		.10	2.08	
PROGRAM MGMT		.00	2.09	4.18
TOTAL			43.92	87.70

Table A-26. RIA Alternative 2

G/P System Level Cost Summary (1981 M$)

Platform Module No. 5

Cost Element	Development Cost	Unit Cost
Platform	43.92	87.70
Payloads		
27	14.61	3.84
42	10.93	1.74
55	27.65	6.92
Payload Total	53.19	12.50
System Level Costs		
IA&CO	---	0.38
SE&I	3.09	---
System Test		
Test Article	1.25	---
Test Ops	0.78	---
Program Mgmt Dev	1.32	0.15
System Total	6.44	0.53
PROGRAM TOTAL	103.55	100.73

Table A-27. RIA Alternative 2

G/P Platform Preliminary Cost Estimate (1981 M$)

Platform Module No. 6

COST ELEMENT	SIZE PARAMETER	COMMONALITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	2784.3	.38	8.21	5.66
STRUCTURE (SEC)	146.5	.67	3.45	.61
TOOLING		.38	1.10	
THERMAL CTL	50.0	.20	1.59	.72
ACS AVIONICS	106.5	.02	.70	3.68
ACS AMCD		.00		
RCS	370.2	.05	.74	2.78
EPS SOLAR ARRAY		.00		
EPS BATTERIES	2.6	.00		.31
EPS COND & DIST	100.0	.00		.67
TT&C	12.7	.00		.56
R&D AVIONICS	12.7	.00		.19
R&D MECH	34.3	.00		.18
FLIGHT SOFTWARE	30000.0	.05	.38	
SUBTOTAL			16.17	15.35
IA&CO		.00		1.84
SUSTAIN ENG		.00		1.29
SE&I		1.00	2.83	
SYSTEM TEST		.00		
TEST ART		.05	1.54	
TEST OPS		.20	1.52	
GSE		.05	.16	
GND SOFTWARE	30000.0	.05	.03	
FSE	1500.0	.01	.22	
FACILITIES & STE		.03		
SPARES		.00		
PROGRAM MGMT		.00	1.13	.92
TOTAL			23.66	19.41

Table A-28. RIA Alternative 2

G/P System Level Cost Summary (1981 M$)

Platform Module No. 6

Cost Element	Development Cost	Unit Cost
Platform	23.66	19.41
Payloads		
4	40.56	23.80
6	35.72	21.60
7	31.72	17.15
9	51.30	26.00
71	58.31	18.22
Payload Total	217.61	106.77
System Level Costs		
IA&CO	---	3.20
SE&I	12.62	---
System Test		
Test Article	10.68	---
Test Ops	6.62	---
Program Mgmt Dev	5.85	1.23
System Total	35.77	4.43
PROGRAM TOTAL	277.04	130.61

Table A-29. AA-2 Alternative 2

G/P Platform Preliminary Cost Estimate (1981 M$)

Platform Module No. 1

COST ELEMENT	SIZE PARAMETER	COMMONALITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	2833.7	1.00	21.58	5.73
STRUCTURE (SEC)	149.5	1.00	5.20	.62
TOOLING		1.00	2.92	
THERMAL CTL	1113.0	1.00	16.75	5.69
ACS AVIONICS	106.5	1.00	35.12	3.68
ACS AMCD	500.0	1.00	8.08	2.80
RCS	413.3	1.00	15.13	3.04
EPS SOLAR ARRAY	27.5	1.00	25.56	33.04
EPS BATTERIES	2.6	1.00	4.03	3.40
EPS CCND & DIST	1277.8	1.00	21.36	6.97
TT&C	106.5	1.00	7.35	3.03
R&D AVIONICS	100.0	1.00	30.17	1.31
R&D MECH	137.0	1.00	4.09	.45
FLIGHT SOFTWARE	60000.0	1.00	15.00	
SUBTOTAL			212.35	69.76
IA&CO		.00		8.37
SUSTAIN ENG		.00		5.86
SE&I		1.00	37.16	
SYSTEM TEST		.00		
TEST ART		1.00	90.05	
TEST OPS		1.00	22.31	
GSE		1.00	42.47	
GND SOFTWARE	30000.0	1.00	1.89	
FSF	1500.0	1.00	22.13	
FACILITIES & STE		1.00	21.86	
SPARES		1.00	20.93	
PROGRAM MGMT		.00	23.56	4.20
TOTAL			494.69	88.19

Table A-30. AA-2 Alternative 2

G/P System Level Cost Summary (1981 M$)

Platform Module No. 1

Cost Element	Development Cost	Unit Cost
Platform	494.69	88.19
Payloads		
No. 3 - TV Distribution	35.72	21.60
No. 11 - IPL (2 required)	22.43	21.60
AA-2 Master Switch	14.41	5.98
Interservice Switch	6.44	2.20
Payload Total	79.00	51.38
System Level Costs		
IA&CO	---	1.54
SE&I	4.58	---
System Test		
Test Article	5.14	---
Test Ops	3.19	---
Program Mgmt	2.23	0.59
System Total	15.14	2.13
PROGRAM TOTAL	588.83	141.70

Table A-31. AA-2 Alternative 2

G/P Platform Preliminary Cost Estimate (1981 M$)

Platform Module No. 2

COST ELEMENT	SIZE PARAMETER	COMMONALITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	2398.8	.35	6.94	5.12
STRUCTURE (SEC)	125.3	.67	3.20	.55
TOOLING		.35	.89	
THERMAL CTL	50.0	.50	3.98	.72
ACS AVIONICS	106.5	.05	1.76	3.68
ACS AMCD	500.0	.00		
RCS	377.8	.30	4.47	2.82
EPS SOLAR ARRAY		.00		
EPS BATTERIES	2.6	.00		.31
EPS COND & DIST	100.0	.50	1.39	.67
TT&C	12.7	.00		.56
R&D AVIONICS	12.7	.10	2.24	.19
R&D MECH	34.3	.10	.20	.18
FLIGHT SOFTWARE	30000.0	.30	2.25	
SUBTOTAL			27.32	14.81
IA&CO		.00		1.78
SUSTAIN ENG		.00		1.24
SE&I		1.00	4.78	
SYSTEM TEST		.00		
TEST ART		.20	5.93	
TEST OPS		.50	3.67	
GSE		.10	.55	
GND SOFTWARE	30000.0	.15	.28	
FSE	1500.0	.02	.44	
FACILITIES & STE		.00		
SPARES		.30	1.33	
PROGRAM MGMT		.00	2.22	.89
TOTAL			46.52	18.72

Table A-32. AA-2 Alternative 2

G/P System Level Cost Summary (1981 M$)

Platform Module No. 2

Cost Element		Development Cost	Unit Cost
Platform		46.52	18.72
Payloads			
1.1 KuVE		30.27	17.32
1.1 KuHE		7.72	13.94
1.1 KuHW		9.40	18.13
1.1 KuVW		5.99	9.94
1.3 KaUE		38.23	23.65
1.3 KaUW		11.04	22.49
Payload Total		102.65	105.47
System Level Costs			
IA&CO		---	3.16
SE&I		5.95	---
System Test			
Test Article		10.55	---
Test Ops		6.54	---
Prog Mgmt Dev	2% PLD	2.05	---
	5% SYS	1.15	---
Unit	1% PLU	---	1.05
	5% SYS	---	0.16
System Total		26.24	4.37
PROGRAM TOTAL		175.41	128.56

Table A-33. AA-2 Alternative 2

G/P Platform Preliminary Cost Estimate (1981 M$)

Platform Module No. 3

COST ELEMENT	SIZE PARAMETER	COMMONALITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	1946.1	.14	2.50	4.45
STRUCTURE (SEC)	102.4	.67	2.88	.48
TOOLING		.14	.30	
THERMAL CTL	50.0	.20	1.59	.72
ACS AVIONICS	106.5	.02	.70	3.68
ACS AMCD	500.0	.00		
RCS	342.3	.05	.73	2.61
EPS SOLAR ARRAY		.00		
EPS BATTERIES	2.6	.00		.31
EPS COND & DIST	100.0	.00		.67
TT&C	12.7	.00		.56
R&D AVIONICS	12.7	.00		.19
R&D MECH	34.3	.00		.18
FLIGHT SOFTWARE	30000.0	.05	.38	
SUBTOTAL			9.08	13.85
IA&CO		.00		1.66
SUSTAIN ENG		.00		1.16
SE&I		1.00	1.59	
SYSTEM TEST		.00		
TEST ART		.05	1.39	
TEST OPS		.30	2.06	
GSE		.05	.09	
GND SOFTWARE	30000.0	.05	.09	
FSE	1500.0	.01	.22	
FACILITIES & STE		.00		
SPARES		.10	.42	
PROGRAM MGMT		.00	.75	.83
TOTAL			15.68	17.51

Table A-34. AA-2 Alternative 2

G/P System Level Cost Summary (1981 M$)

Platform Module No. 3

Cost Element	Development Cost	Unit Cost
Platform	15.68	17.51
Payloads		
1.1 KuVM	6.01	9.99
1.1 KuHP	7.02	12.28
1.1 KuVB	7.44	13.27
1.1 KuHA	6.87	11.95
0.5 Educational TV	39.19	24.45
Payload Total	66.53	71.94
System Level Costs		
IA&CO (3% PLU)	---	2.16
SE&I (5.8% PLD)	3.86	---
System Test		
Test Article (10% PLU)	7.19	---
Test Ops (6.2% PLU)	4.46	---
Prog Mgmt Dev 2% PLD	1.33	---
5% SYS	0.78	---
Unit 1% PLU	---	0.72
5% SYS	---	0.11
System Total	17.62	2.99
PROGRAM TOTAL	99.83	92.44

Table A-35. AA-2 Alternative 2

G/P Platform Preliminary Cost Estimate (1981 M$)

Platform Module No. 4

COST ELEMENT	SIZE PARAMETER	COMMONALITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	2427.8	.18	3.59	5.16
STRUCTURE (SEC)	127.8	.67	3.22	.55
TOOLING		.18	.46	
THERMAL CTL	50.0	.20	1.59	.72
ACS AVIONICS	106.5	.02	.70	3.68
ACS AMCD	500.0	.00		
RCS	352.4	.05	.74	2.67
EPS SOLAR ARRAY		.00		
EPS BATTERIES	2.6	.00		.31
EPS CCND & DIST	100.0	.00		.67
TT&C	12.7	.00		.56
R&D AVIONICS	12.7	.00		.19
R&D MECH	34.3	.00		.18
FLIGHT SOFTWARE	30000.0	.05	.38	
SUBTOTAL			10.67	14.70
IA&CO		.00		1.76
SUSTAIN ENG		.00		1.23
SE&I		1.00	1.87	
SYSTEM TEST		.00		
TEST ART		.05	1.47	
TEST OPS		.20	1.46	
GSE		.05	.11	
GND SOFTWARE	30000.0	.05	.09	
FSE	1500.0	.01	.22	
FACILITIES & STE		.00		
SPARES		.10	.44	
PROGRAM MGMT		.00	.82	.88
TOTAL			17.15	18.58

Table A-36. AA-2 Alternative 2

G/P System Level Cost Summary (1981 M$)

Platform Module No. 4

Cost Element	Development Cost	Unit Cost
Platform	17.15	18.58
Payloads		
1.3 CTG/CRG	41.10	26.05
12 Data Collection	22.43	10.80
19 VIS & IR Radiometer	39.33	9.32
31 DMSP Data Relay	18.62	5.31
Payload Total	121.48	51.48
System Level Costs		
IA&CO (3% PLU)	---	1.54
SE&I (5.8% PLD)	7.05	---
System Test		
Test Article (10% PLU)	5.15	---
Test Ops (6.2% PLU)	3.19	---
Prog Mgmt Dev 2% PLD	2.43	---
5% SYS	0.77	---
Unit 1% PLU	---	0.51
5% SYS	---	0.08
System Total	18.59	2.13
PROGRAM TOTAL	157.22	72.19

Table A-37. AA-2 Alternative 2

G/P Platform Preliminary Cost Estimate (1981 M$)

Platform Module No. 5

COST ELEMENT	SIZE PARAMETER	COMMONALITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	2273.7	.33	6.37	4.94
STRUCTURE (SEC)	119.7	.67	3.12	.53
TOOLING		.33	.80	
THERMAL CTL	1194.1	.30	5.11	5.97
ACS AVIONICS	106.5	.05	1.76	3.68
ACS AMCD	500.0	.00		2.80
RCS	408.2	.10	1.51	3.01
EPS SOLAR ARRAY	29.5	.03	.80	35.07
EPS BATTERIES	2.6	.00		3.71
EPS COND & DIST	1277.8	.10	2.14	6.97
TT&C	106.5	.00		3.03
R&D AVIONICS	100.0	.00		1.31
R&D MECH	137.0	.00		.45
FLIGHT SOFTWARE	60000.0	.10	1.50	
SUBTOTAL			23.10	71.47
IA&CO		.00		8.58
SUSTAIN ENG		.00		6.00
SE&I		1.00	4.04	
SYSTEM TEST		.00		
TEST ART		.10	9.04	
TEST OPS		.30	6.72	
GSE		.10	.46	
GND SOFTWARE	30000.0	.10	.19	
FSE	1500.0	.01	.22	
FACILITIES & STE		.00		
SPARES		.10	2.14	
PROGRAM MGMT		.00	2.30	4.30
TOTAL			48.22	90.35

Table A-38. AA-2 Alternative 2

G/P System Level Cost Summary (1981 M$)

Platform Module No. 5

Cost Element	Development Cost	Unit Cost
Platform	48.22	90.35
Payloads		
2.2 KaUE	9.23	17.70
27 RF Interferometer	14.61	3.84
11 IPL (2 required)	---	21.60
Master Switch	---	5.98
Payload Total	23.84	41.92
System Level Costs		
IA&CO (3% PLU)	---	1.26
SE&I (5.8% PLD)	1.38	---
System Test		
Test Article (10% PLU)	4.19	---
Test Ops (6.2% PLU)	2.60	---
Prog Mgmt Dev 2% PLD	0.48	---
5% SYS	0.41	---
Unit 1% PLU	---	0.42
5% SYS	---	0.06
System Total	9.06	1.74
PROGRAM TOTAL	81.12	134.01

Table A-39. AA-2 Alternative 2

G/P Platform Preliminary Cost Estimate (1981 M$)

Platform Module No. 6

COST ELEMENT	SIZE PARAMETER	COMMONALTITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	2743.3	.39	8.27	5.60
STRUCTURE (SEC)	144.4	.67	3.42	.60
TOOLING		.39	1.11	
THERMAL CTL	50.0	.20	1.59	.72
ACS AVIONICS	106.5	.02	.70	3.68
ACS AMCD	500.0	.00		
RCS	370.2	.05	.74	2.78
EPS SOLAR ARRAY		.00		
EPS BATTERIES	2.6	.00		.31
EPS CCND & DIST	100.0	.00		.67
TT&C	12.7	.00		.56
R&D AVIONICS	12.7	.00		.19
R&D MECH	34.3	.00		.18
FLIGHT SOFTWARE	30000.0	.05	.38	
SUBTOTAL			16.21	15.29
IA&CO		.00		1.83
SUSTAIN ENG		.00		1.28
SE&I		1.00	2.84	
SYSTEM TEST		.00		
TEST ART		.05	1.53	
TEST OPS		.20	1.52	
GSE		.05	.16	
GND SOFTWARE	30000.0	.05	.09	
FSE	1500.0	.01	.22	
FACILITIES & STE		.00		
SPARES		.00		
PROGRAM MGMT		.00	1.13	.92
TOTAL			23.70	19.33

Table A-40. AA-2 Alternative 2

G/P System Level Cost Summary (1981 M$)

Platform Module No. 6

Cost Element	Development Cost	Unit Cost
Platform	23.70	19.33
Payloads		
2.2 CTG/CRG	34.37	20.52
6 Direct to Home TV	35.72	21.60
7 Air Mobile	31.72	17.15
9 Land Mobile	51.30	26.00
Payload Total	153.11	85.27
System Level Costs		
IA&CO (3% PLU)	---	2.56
SE&I (5.8% PLD	8.88	---
System Test		
Test Article (10% PLU)	8.53	---
Test Ops (6.2% PLU)	5.29	---
Prog Mgmt Dev 2% PLD	3.06	---
5% SYS	1.14	---
Unit 1% PLU	---	0.85
5% SYS	---	0.13
System Total	26.90	3.54
PROGRAM TOTAL	203.71	108.14

Table A-41. AA-2 Alternative 2

G/P Platform Preliminary Cost Estimate (1981 M$)

Platform Module No. 7

COST ELEMENT	SIZE PARAMETER	COMMONALITY FACTOR (%NEW)	DEVELOPMENT COST	UNIT COST
FLIGHT VEHICLE				
STRUCTURE (PRI)	2201.4	.16	3.04	4.84
STRUCTURE (SEC)	115.9	.67	3.07	.52
TOOLING		.16	.38	
THERMAL CTL	50.0	.20	1.59	.72
ACS AVIONICS	106.5	.02	.70	3.68
ACS AMCD	500.0	.00		
RCS	408.2	.05	.75	3.01
EPS SOLAR ARRAY		.00		
EPS BATTERIES	2.6	.00		.31
EPS COND & DIST	100.0	.00		.67
TT&C	12.7	.00		.56
R&D AVIONICS	12.7	.00		.19
R&D MECH	34.3	.00		.18
FLIGHT SOFTWARE	30000.0	.05	.38	
SUBTOTAL			9.90	14.67
IA&CO		.00		1.76
SUSTAIN ENG		.00		1.23
SE&I		1.00	1.73	
SYSTEM TEST		.00		
TEST ART		.05	1.47	
TEST OPS		.10	.73	
GSF		.05	.10	
GND SOFTWARE	30000.0	.05	.09	
FSE	1500.0	.01	.22	
FACILITIES & STE		.00		
SPARES		.00		
PROGRAM MGMT		.00	.71	.88
TOTAL			14.96	18.55

Table A-42. AA-2 Alternative 2

G/P System Level Cost Summary (1981 M$)

Platform Module No. 7

Cost Element	Development Cost	Unit Cost
Platform	14.96	18.55
Payloads		
2.1 KuVE	5.57	9.02
2.1 KuHE	5.65	9.19
4 Tracking & Data Relay	40.56	23.80
27 Lightning Mapper	27.65	6.92
18 Atmos Sounder	21.02	4.59
20 Microwave Radiometer	15.55	4.17
32 OLS Cloud Imager	21.53	3.34
33 Materials Exposure	1.06	0.18
38 Cloud Height Sensor	12.43	1.31
42 Global UV Radiance	10.93	1.74
43 Magnetic Substorm Monitor	4.21	0.73
52 Buss Eval	21.53	3.34
54 DoD EHF Exp	20.22	5.93
55 DoD Laser Comm	27.65	6.92
56 Fiber Optics Demo	1.06	0.18
71 Earth Optical Telescope	58.31	18.22
Payload Total	294.93	99.58
System Level Costs		
IA&CO (3% PLU)	---	2.99
SE&I (5.8% PLD)	17.11	---
System Test		
Test Article (10% PLU)	9.96	---
Test Ops (6.2% PLU)	6.17	---
Prog Mgmt Dev 2% PLD	5.90	---
5% SYS	1.66	---
Unit 1% PLU	---	1.00
5% SYS	---	0.15
System Total	40.80	4.14
PROGRAM TOTAL	350.69	122.27